

ECM TECHNIQUES GENERATION



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13. ABSTRACT (Maximum 200 Words) The goal of this session is to provide a comprehensive look at functional areas of ECM system and trade-off considerations, i.e. apertures, receivers/processors, counter/measurer techniques generators, and high power sources. Also to a provide comprehensive look at techniques, i.e. generators, system architectures, interaction between jamming and radar processing, trades & drivers, and processes/tools				
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INTRODUCTION



GOAL OF SESSION

- . PROVIDE COMPREHENSIVE LOOK AT FUNCTIONAL AREAS OF ECM SYSTEM AND TRADE-OFF CONSIDERATIONS
 - APERTURES
 - RECEIVERS/PROCESSORS
 - COUNTERMEASURE/TECHNIQUES GENERATORS
 - HIGH POWER SOURCES

GOAL OF TOPIC

- . PROVIDE COMPREHENSIVE LOOK AT TECHNIQUES GENERATORS
 - SYSTEM ARCHITECTURES
 - INTERACTION BETWEEN JAMMING AND RADAR PROCESSING
 - TRADES & DRIVERS
 - PROCESSES/TOOLS

AGENDA



SURVIVABILITY FACTORS

ECM SYSTEM ARCHITECTURES

RADAR COUNTERMEASURES

- RANGE
- VELOCITY
- ANGLE

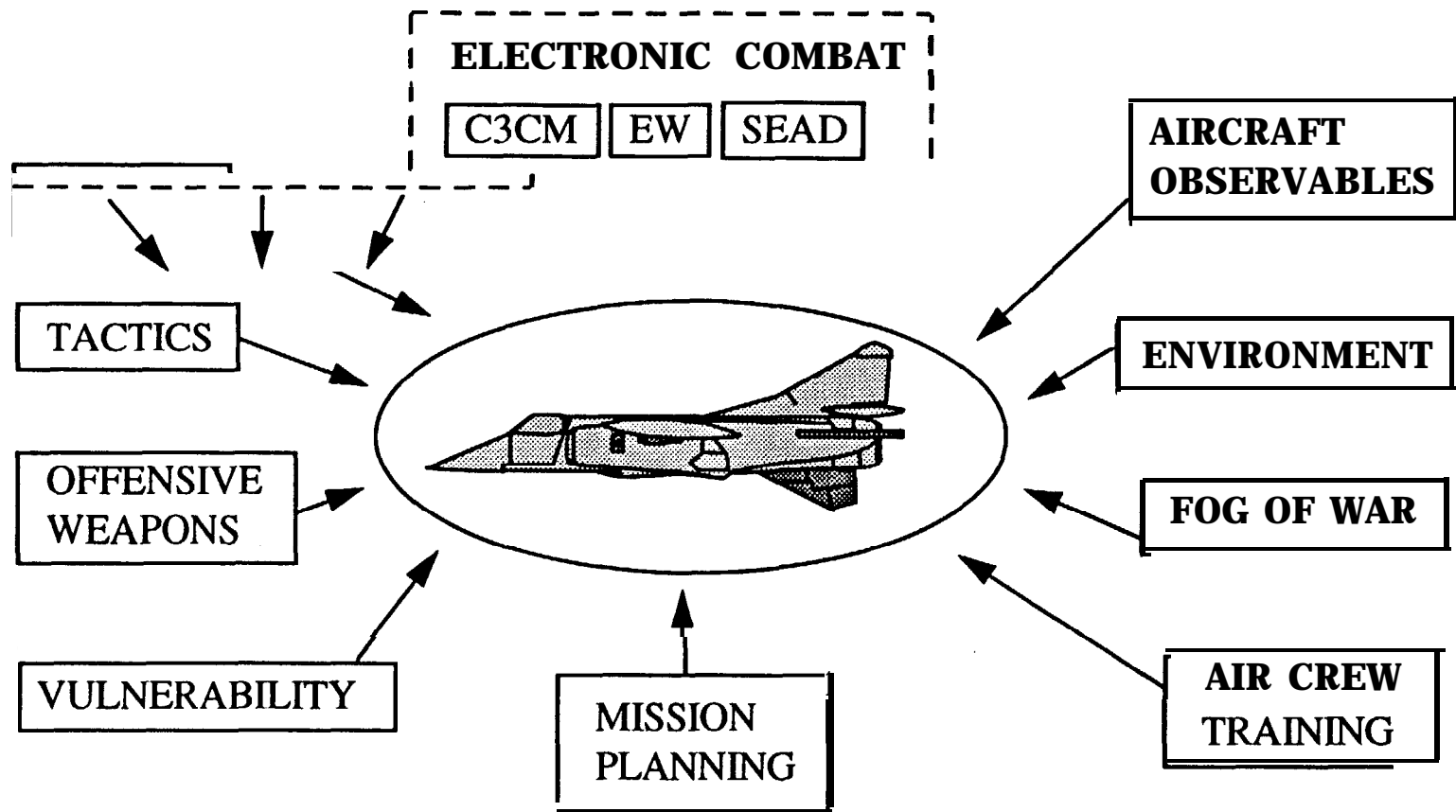
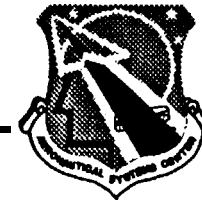
MISSILE COUNTERMEASURES

COUNTERMEASURES WRAP-UP

ECM ANALYSIS - TOOLS AND PROCESSES

AIRCRAFT SURVIVABILITY FACTORS

(EC IS A CONTRIBUTOR TO A/C SURVIVABILITY)

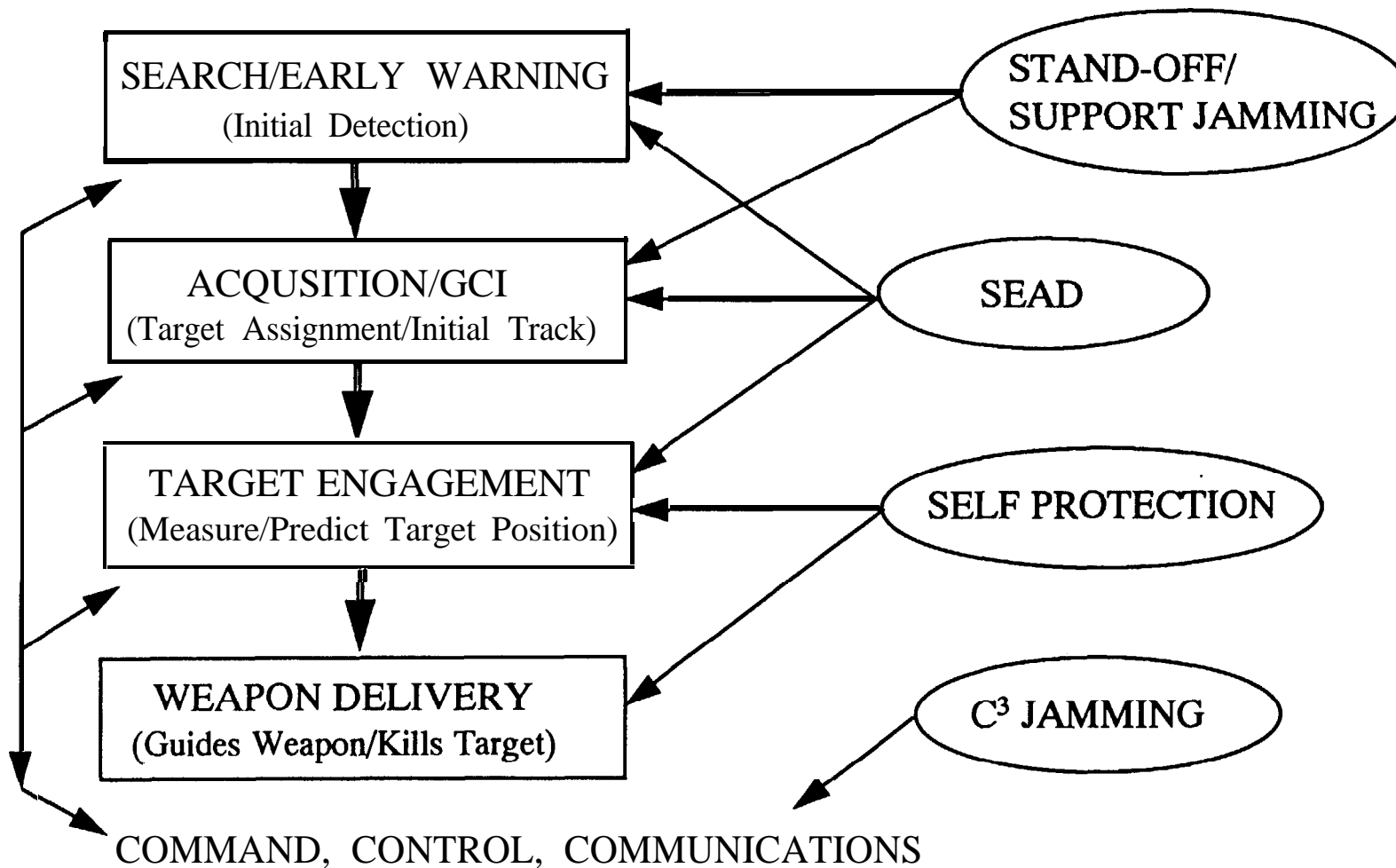


EWRESPONSE TO ENEMY AIR DEFENSE

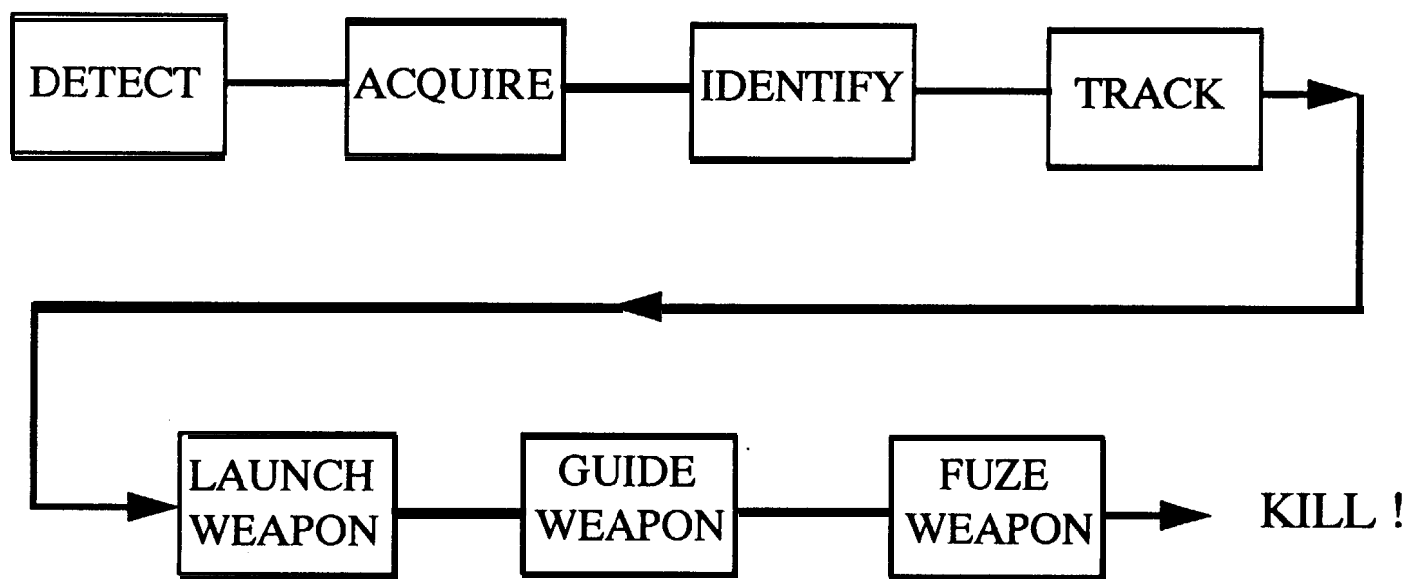


THREATIADS

ECFORCEELEMENTS



ENGAGEMENT PROCESS



SURVIVABILITY FACTORS



JAM TO SIGNAL RATIO (J/S) - SELF SCREENING

- RATIO OF JAMMER POWER TO TARGET RETURN POWER

J/S = f (ERP, RANGE, TARGET SIGNATURE, BANDWIDTH MATCH)

$$J/S = \frac{P_J G_J}{P_T G_T} \cdot \frac{4\pi R^2}{1} \cdot \frac{\sigma}{1} \cdot \frac{B_T}{B_J} \quad \text{for } B_J \geq B_T$$

WHERE:

P_J = Jammer TX Power

G_J = Jammer TX Antenna Gain

P_T = Radar TX Power

G_T = Radar Antenna Gain

R = Range - Jammer to Radar

σ = Target Radar Cross Section

B_T = Radar Bandwidth

B_J = Jammer Bandwidth

AGENDA



SURVIVABILITYFACTORS

➔ ECMSYSTEMARCHITECTURES

RADARCOUNTERMEASURES

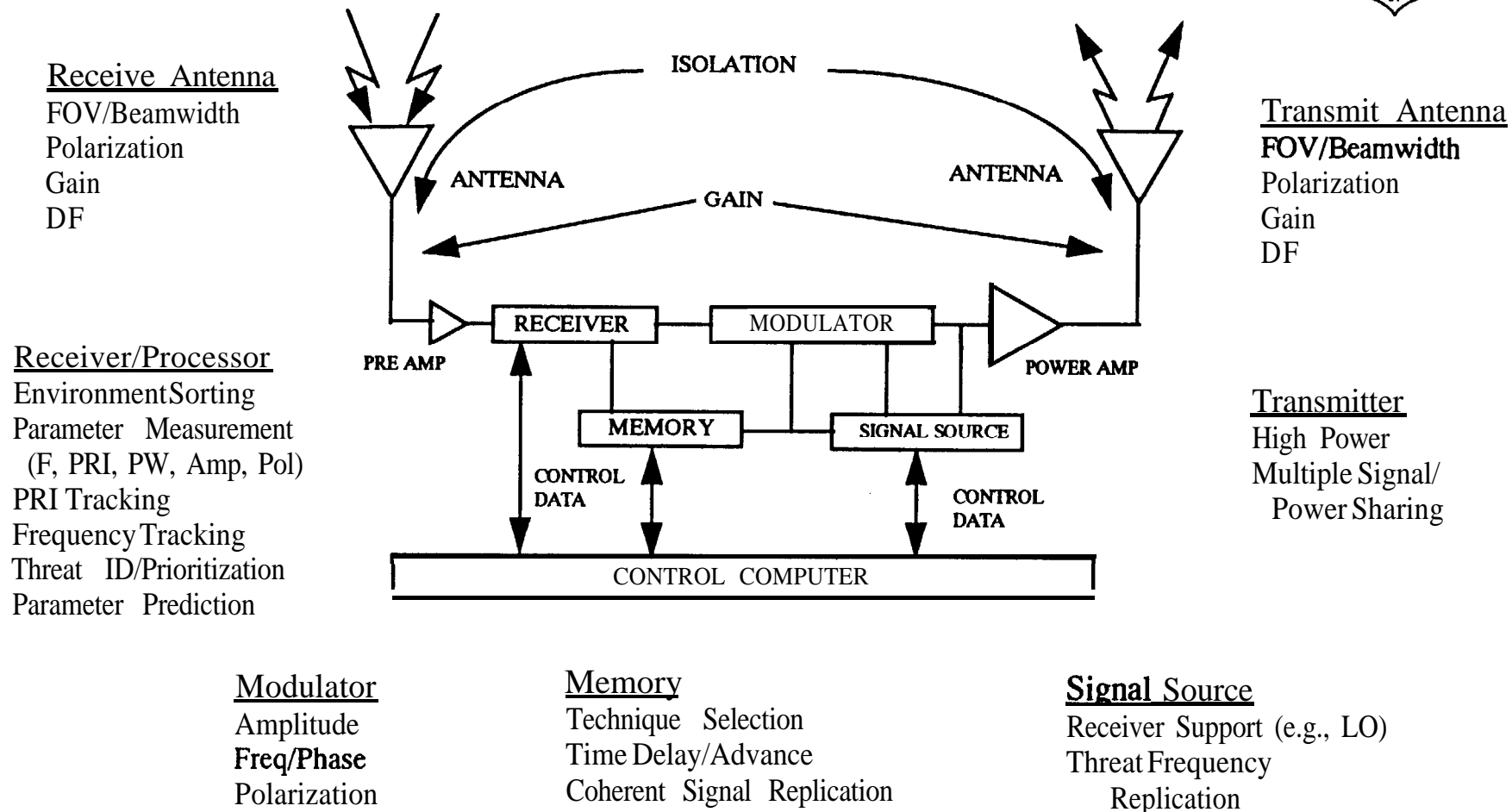
- RANGE
- VELOCITY
- *ANGLE

MISSILECOUNTERMEASURES

COUNTERMEASURESWRAPUP

ECMANALYSIS-TOOLSANDPROCESSES

GENERIC ECM SUITE MODEL



ECM SYSTEM ARCHITECTURES



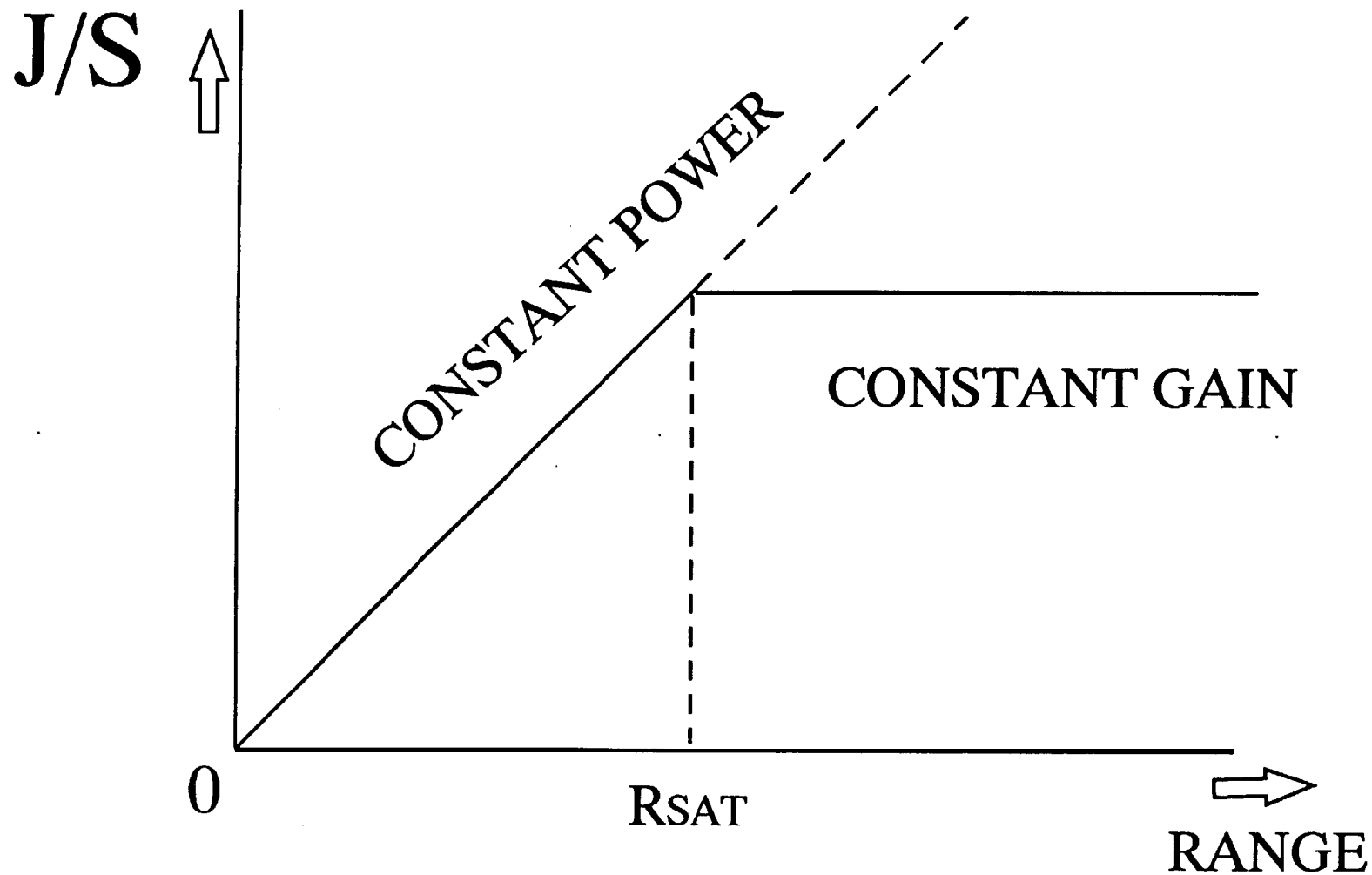
CONSTANT GAIN

- LINEAR AMPLIFICATION OF INPUT SIGNAL
- ELECTRONIC GAIN < ISOLATION
- 4LLOWS R_x TO "LOOK OVER" JAMMING TO SEE THREAT
- PROVIDES CONSTANT J/S UNTIL T_x SATURATION
THEN DEGRADES WITH RANGE (-6dB/OCTAVE)

CONSTANT POWER

- POWER SHARING vs MULTIPLE SIGNALS
- T_x OPERATES AT OR NEARSATURATION REGARDLESS OF INPUT
SIGNAL LEVEL
- ELECTRONIC GAIN MAY BE GREATER THAN ISOLATION
- TYPICALLY, T_x MUST SHUT DOWN FOR R_x TO SEE THREAT
- J/S DECREASES WITH RANGE (-6dB/OCTAVE)

ECM SYSTEM ARCHITECTURES



ECM SYSTEM ARCHITECTURES



TRADES & DRIVERS - CONSTANT GAIN

- ANTENNA ISOLATION
 - LARGE ENOUGH TO COVER TARGET RETURN TO ACCEPTABLE RANGE
 - SUFFICIENT GAIN MARGIN TO ALLOW RECEIVER TO ACQUIRE / MAINTAIN TRACK OF THREAT RADAR
 - DIFFICULT TO COVER LARGE CROSS SECTION TARGETS
- * LOOK-OVER-GAIN MARGIN ALLOWS RECEIVER TO SEE THREAT SIGNAL IN PRESENCE OF JAMMING
- LOOK THROUGH - SERVICE OF SPECIALIZED RECEIVERS
- SYSTEM LOSSES (CABLES, COUPLERS ETC.) WILL DEGRADE DETECTION RANGE AND J/S
- COHERENCY MAINTAINED BY MEMORIZATION/REPEATING INCOMING SIGNAL

ECM SYSTEM ARCHITECTURES



TRADES & DRIVERS - CONSTANT POWER

- ANTENNA ISOLATION - MUST SHUT OFF Tx ON RECEIVE
- LOOKTHROUGH
 - ENOUGH TO ALLOW RECEIVERS TO ACQUIRE/MAINTAIN TRACK
 - SMALL ENOUGH TO PRECLUDE JAMMING **DEGRADATION**
- CHOP
 - *TIMING
 - SPECTRAL SPREADING
- SYSTEM LOSSES (CABLES, COUPLERS, ETC.) WILL DEGRADE RANGE AND J/S
- DIFFICULT TO ACHIEVE/MAINTAIN COHERENCY

SYSTEM APPROACH - COMBINE CONSTANT GAIN /POWER MODES

- **CONSTANTPOWERMODEVS .NON-COHERENT THREATS**
- **CONSTANTGAINMODEVSCOHERENTTHREATS**

AGENDA



SURVIVABILITY FACTORS

ECM SYSTEM ARCHITECTURES

RADAR COUNTERMEASURE TECHNIQUES



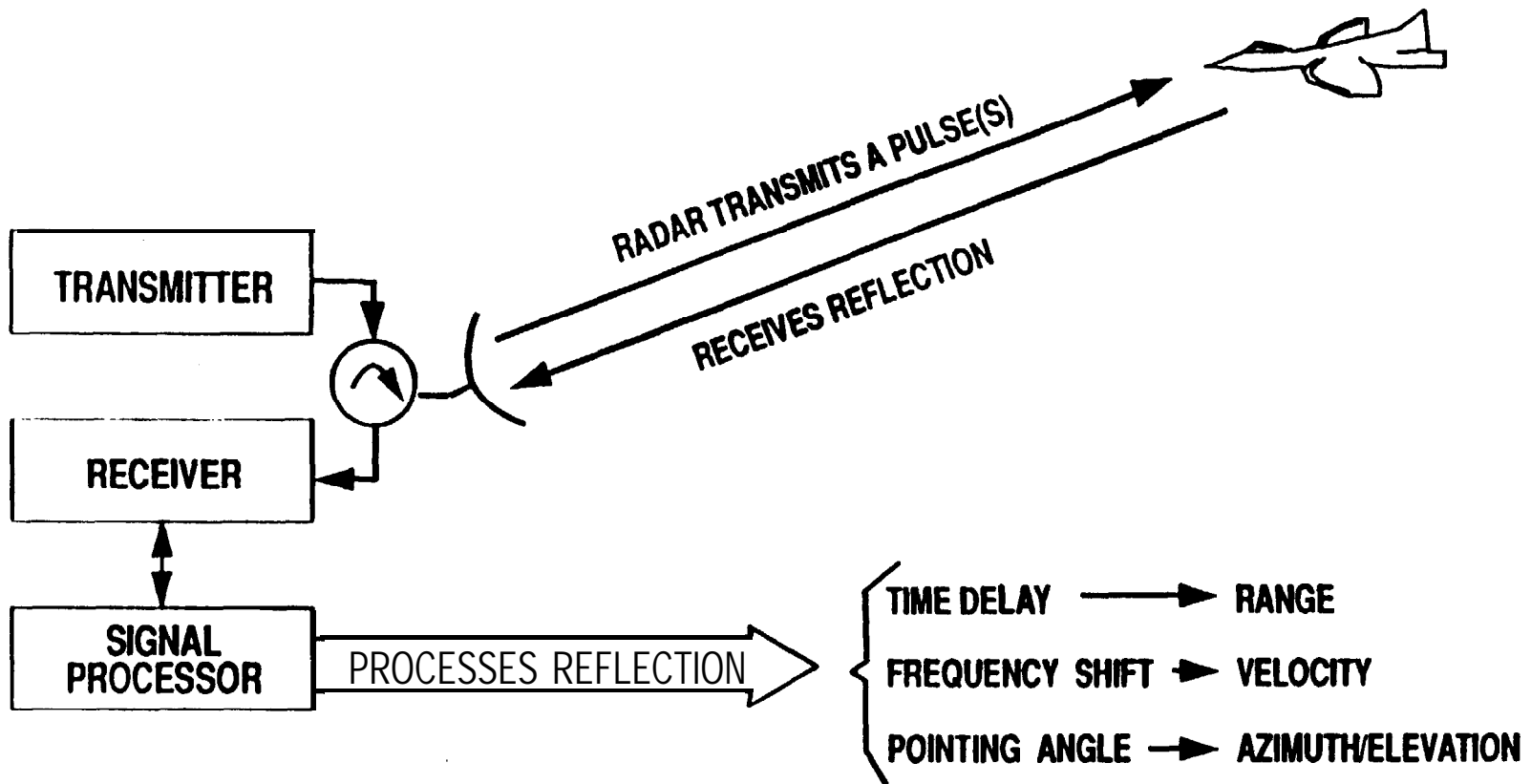
- RANGE
- VELOCITY
- ANGLE

MISSILE COUNTERMEASURES

COUNTERMEASURE SWRAPUP

ECM ANALYSIS- TOOLS AND PROCESSES

BASIC RADAR



RADAR COUNTERMEASURES



NON-COHERENT-PULSE RADAR CHARACTERISTICS

- **RANGE TRACKING**
- **PHASE INFORMATION NOT PRESERVED**
- **HIGH PEAK POWER**
 - **GROUND BASED (~ 120 dBm)**
 - **AIRBORNE (~ 100 dBm)**
- **LOW DUTY CYCLE (< 1%)**
 - **MAY HAVE NARROW PW (< 1 USEC)**
 - **LOW PRF (<SK PPS)**
- **INSTANTANEOUS BANDWIDTH (MEGAHERTZ)**

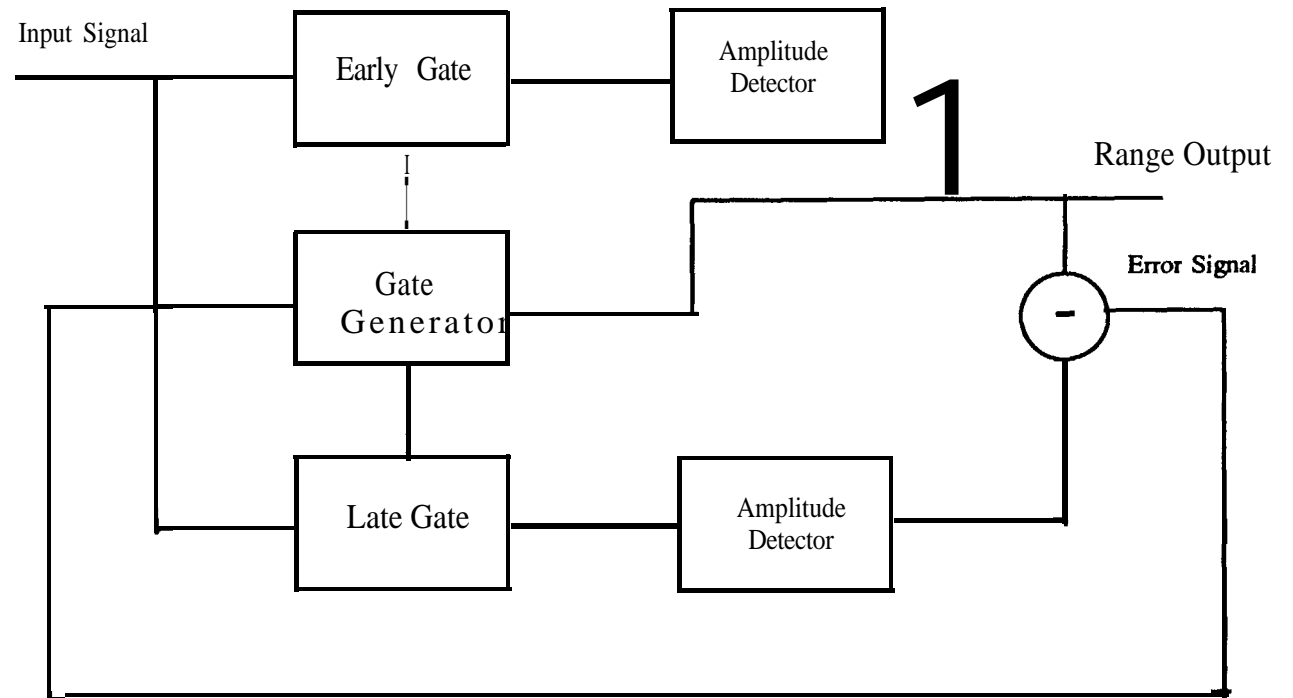
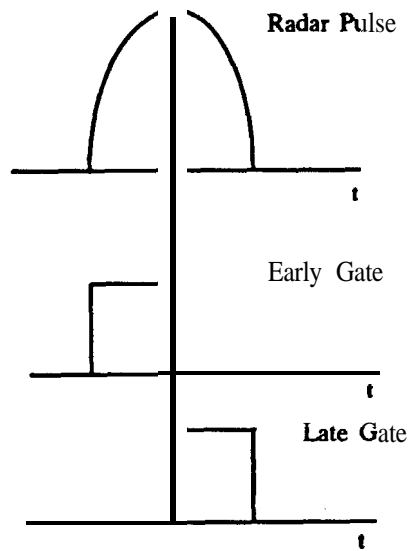
RADAR COUNTERMEASURES



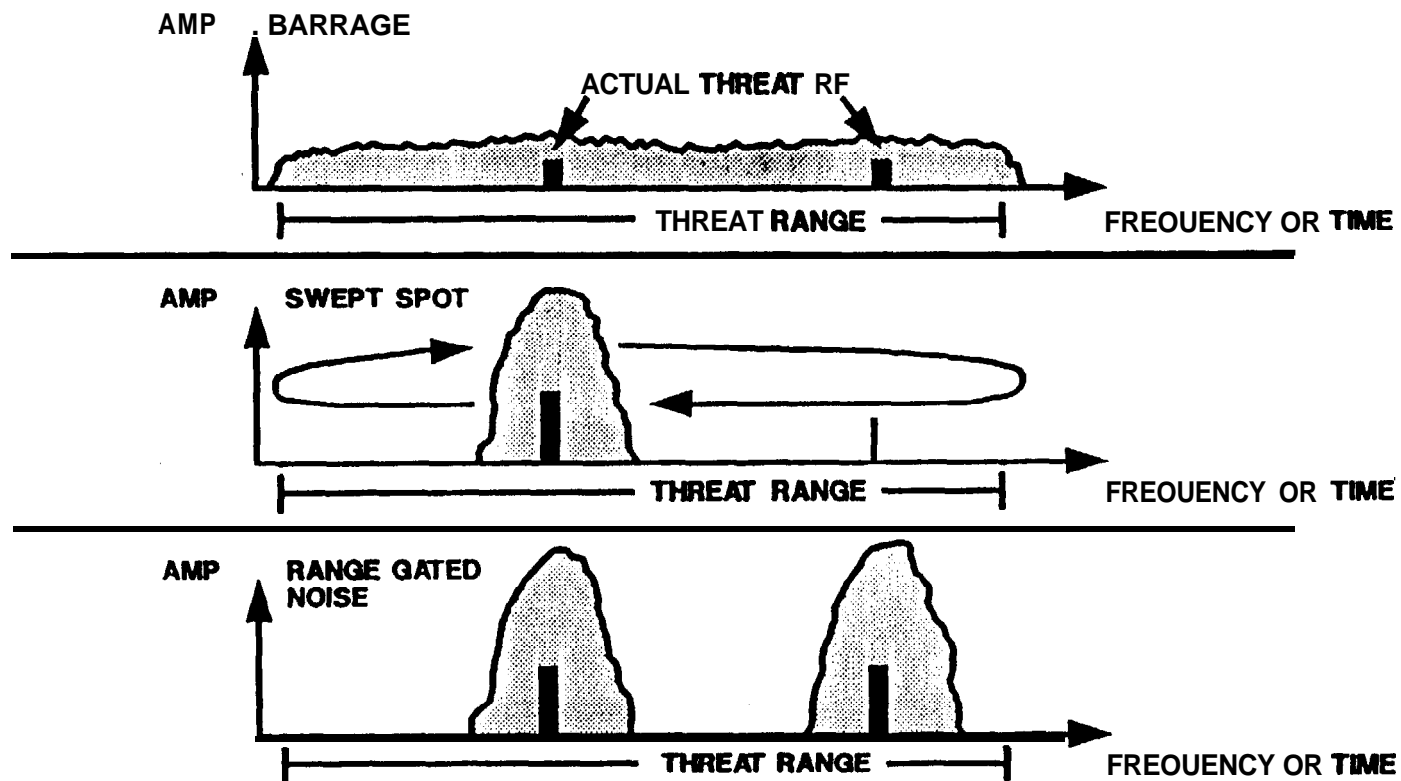
RANGE TECHNIQUES VS PULSE RADAR

- **BROADBAND NOISE**
 - **BARRAGE (BARR)**
 - **SWEPT SPOT (SSN)**
- **POWER MANAGED NOISE**
 - **RANGE GATED NOISE (RGN)**
- **PULSE REPEATER**
 - **RANGE GATE PULL OFF (RGPO)**
- **POWER MANAGED TRANSPONDER**
 - **RANGE GATE PULL IN & OUT (RANRAP)**
 - **RANGE FALSE TARGETS (RFT)**

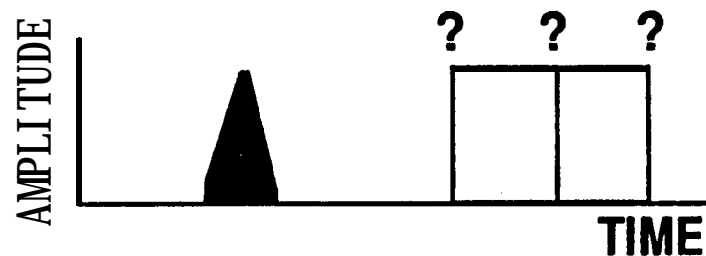
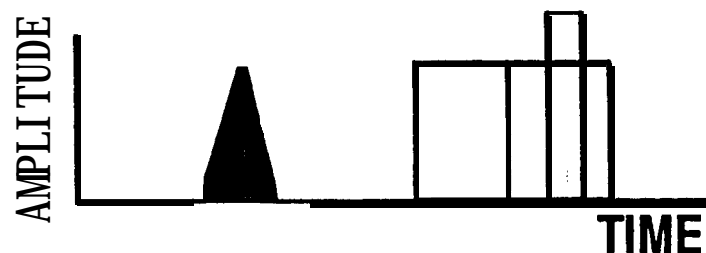
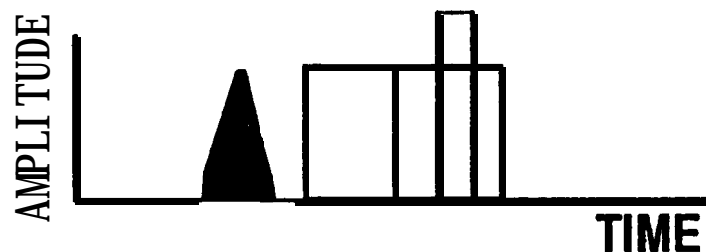
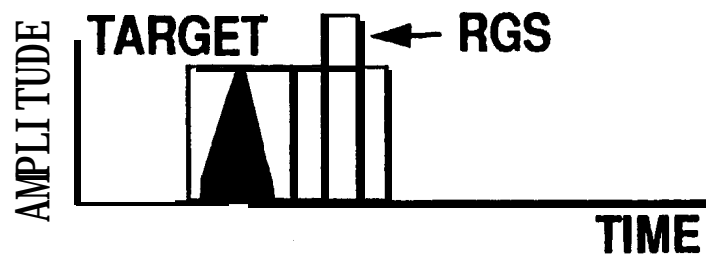
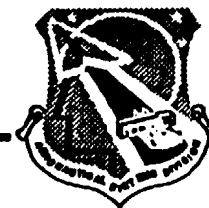
SPLIT GATE RANGE TRACKER



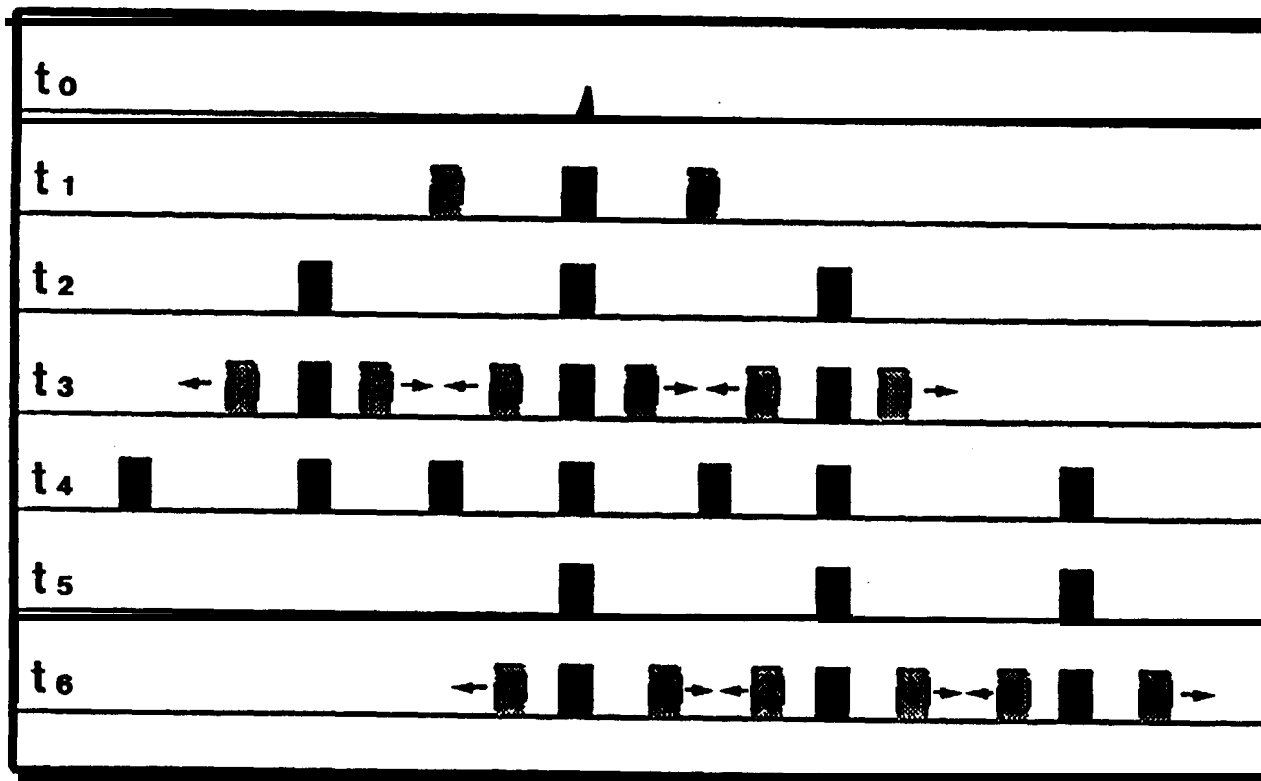
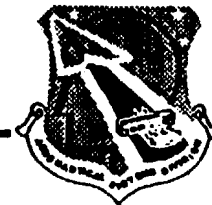
NOISE TECHNIQUES



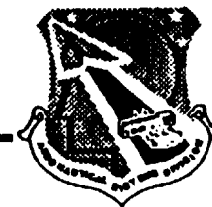
RANGE GATE PULL OFF TIME SEQUENCE



R⁰ NGE F⁰ LSE T⁰ RGETS



CUES



- F² Z Z B² LL



- MOUSE UNDER THE RUG



- F² O² T² P O O C²



- J/S DIFFERENCES



- RATE OF SEPARATION



RADAR COUNTER MEASURES



TRADES & DRIVERS - RANGE TECHNIQUES

. NOISE

- . FREQUENCY SET ON - ACCURACY & SETTLING TIME
- . BANDWIDTH MATCHING
- . LOOK THROUGH RATE

. REPEATER

- . CONSTANT GAIN - ISOLATION/GAIN VERSUS TARGET RCS
- . TIME DELAY THROUGH SYSTEM
- . CONSTANT POWER - CHOP RATE/SPECTRAL SPREADING

. TRANSPONDER

- . SYSTEM COMPLEXITY
- . SIGNAL SORTING/TRACKING
- . FREQUENCY/TIME SET ON ACCURACY
- . LOOK THROUGH RATE

AGENDA



SURVIVABILITYFACTORS

ECMSYSTEMARCHITECI ' URES

RADARCOUNTERMEASURESTECHNIQUES



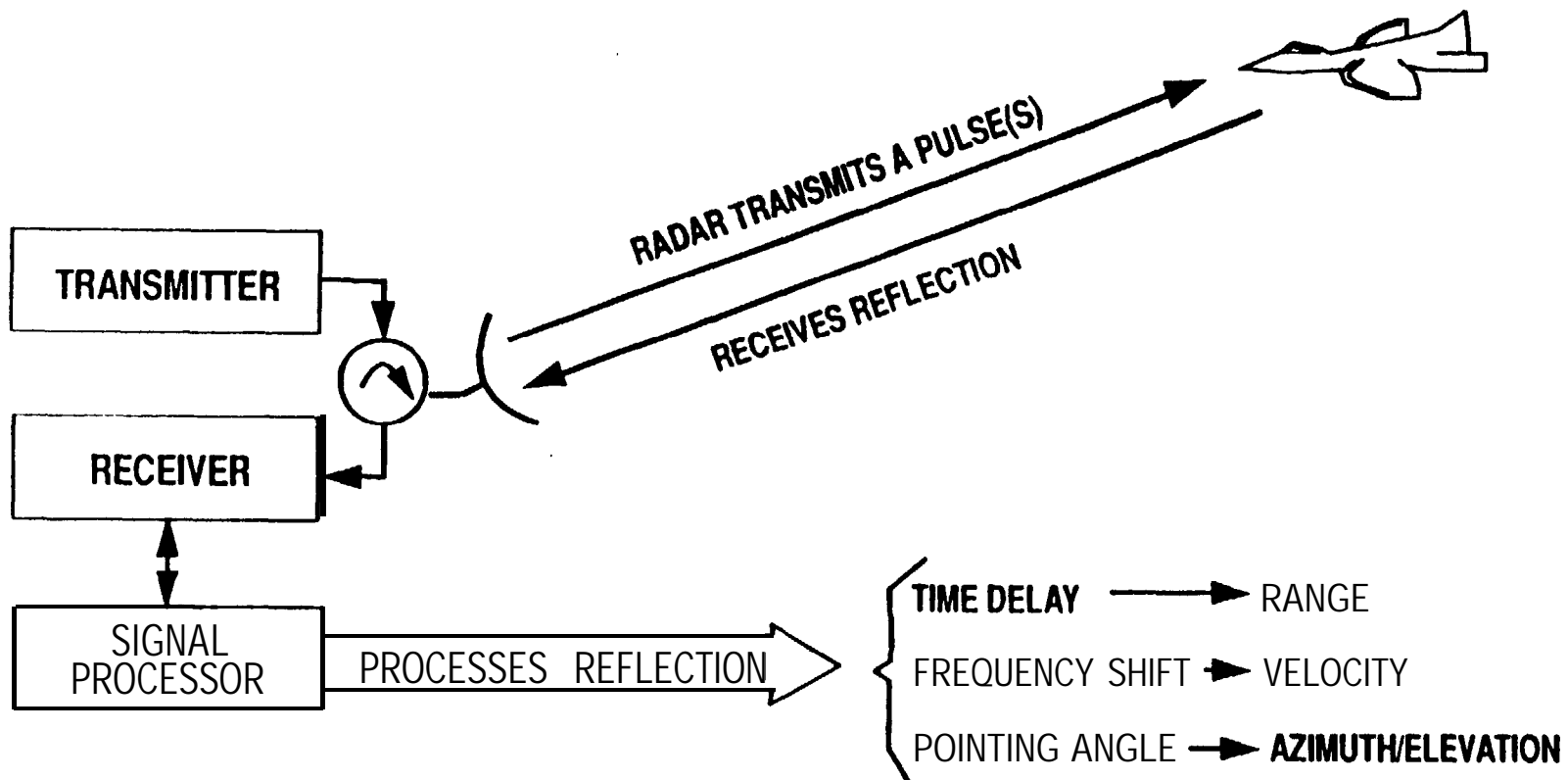
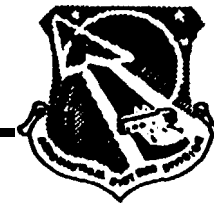
- RANGE
- *VELOCITY
- ANGLE

MISSILECOUNTERMEAURES

COUNTERMEASURESWRAPUP

ECMANALYSIS-TOOLSANDPROCESSES

BASIC RADAR



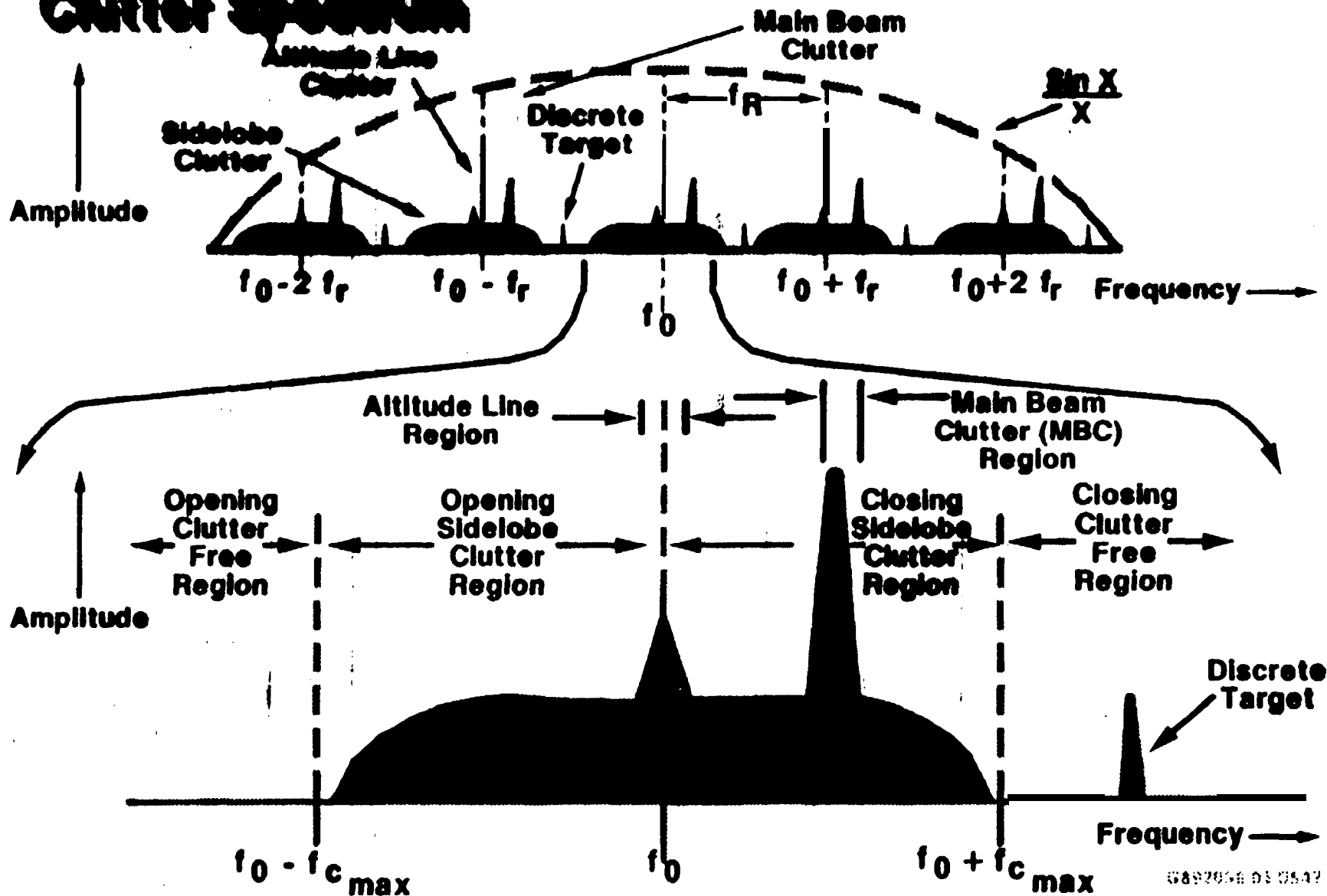
RADAR COUNTERMEASURES



DOPPLER RADAR CHARACTERISTICS

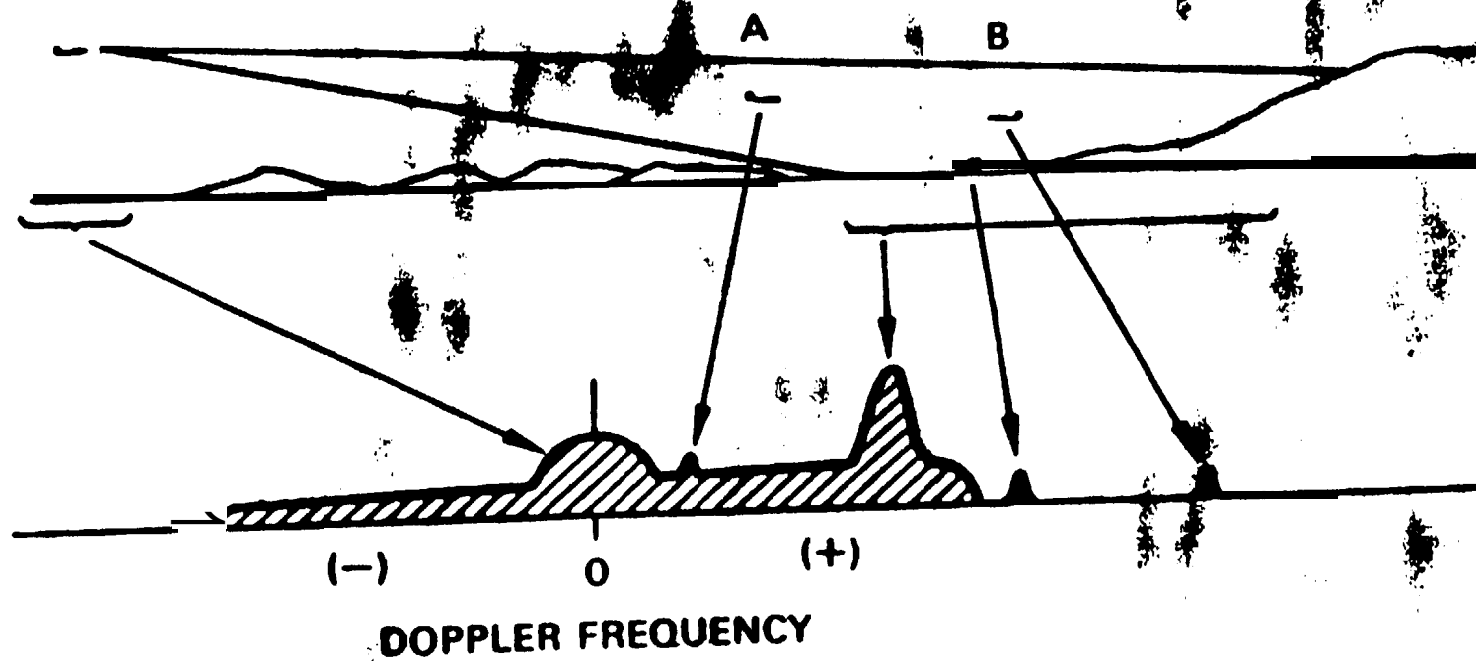
- DOPPLER SHIFT (VELOCITY) TRACKING
- COHERENT RADAR - PHASE INFORMATION PRESERVED
 - STABLE FREQUENCY SOURCE
 - PHASE DETECTOR
- HIGH AVERAGE POWER
 - GROUND BASED (~ 110 dBm)
 - AIRBORNE (~ 90 dBm)
- MEDIUM TO HIGH DUTY CYCLE ($5 < DC < 40$ % TO CW)
 - WIDE PW ($1 \text{ USEC} < PW < CW$)
 - MEDIUM - HIGH PRF (10K-300 K PPS TO CW)
- NARROW INSTANTANEOUS BANDWIDTH (KILOHERTZ)
 - DEPENDS ON COHERENT INTEGRATION OF TARGET RETURN
 - SIGNIFICANTLY DECREASE NOISE & NON-COHERENT JAMMING EFFECTS

Clutter Spectrum



0892006 01 0547

TRUE DOPPLER PROFILE



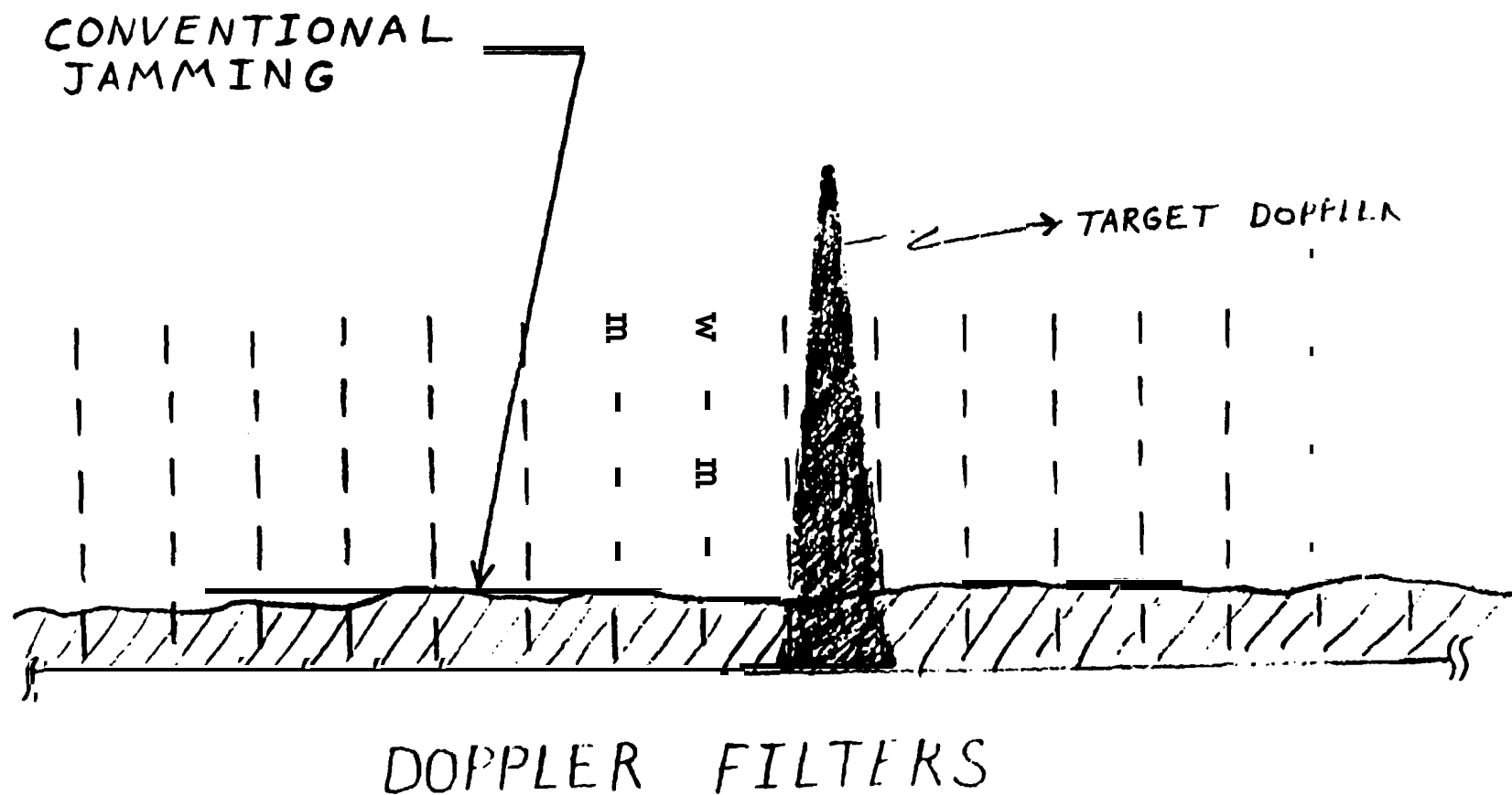
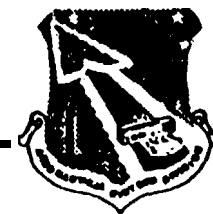
RADAR COUNTERMEASURES



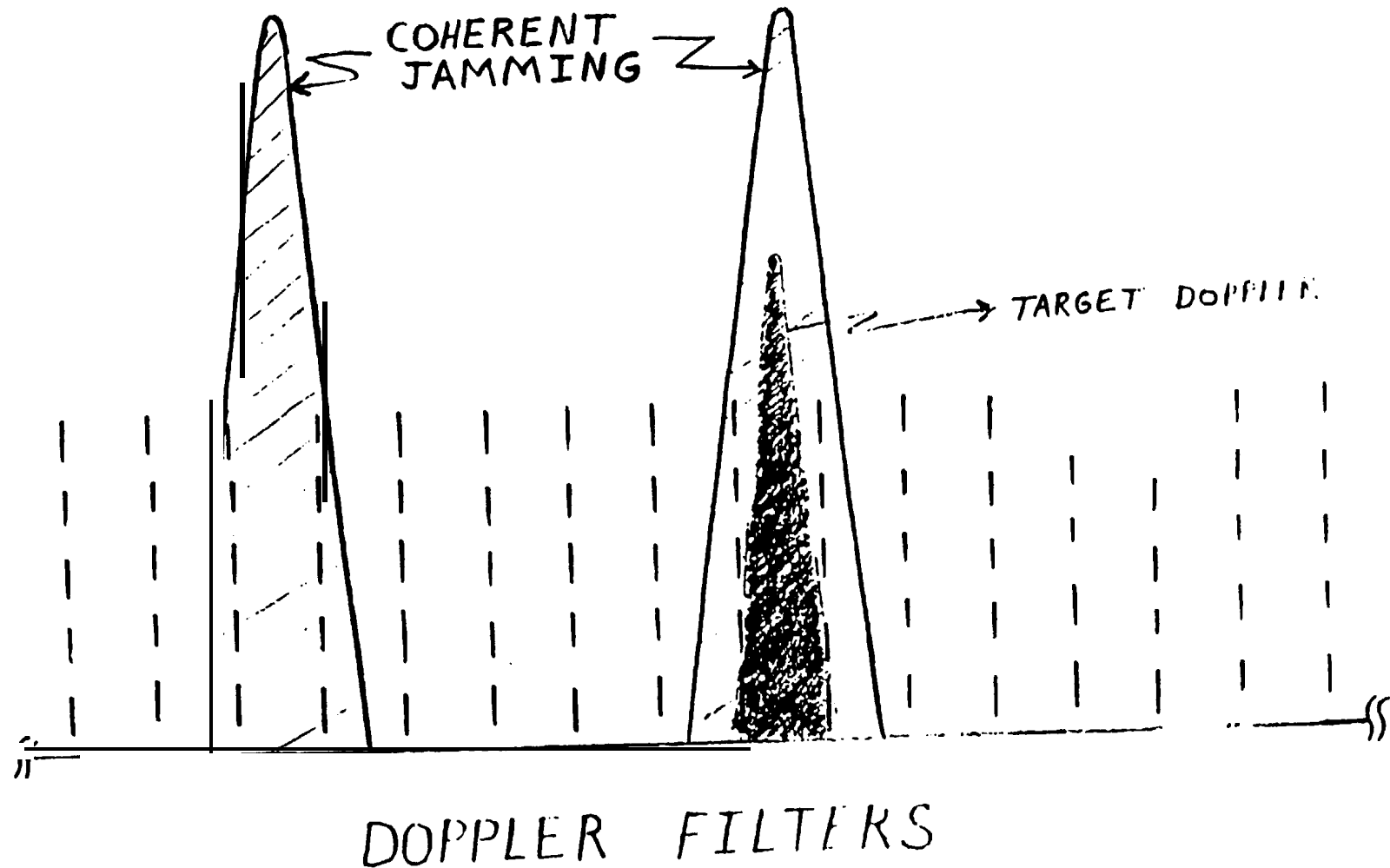
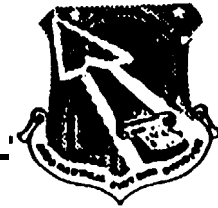
VELOCITY TECHNIQUES VS DOPPLER RADAR

- REPEATER
 - VELOCITY GATE PULL-OFF (VGPO)
 - VELOCITY FALSE TARGETS (VFT)
- TRANSPONDER (DRFM TECHNIQUES)
 - COMBINED RANGE/VELOCITY PULL-OFF
 - RANGE/VELOCITY FALSE TARGETS (R/V FT)

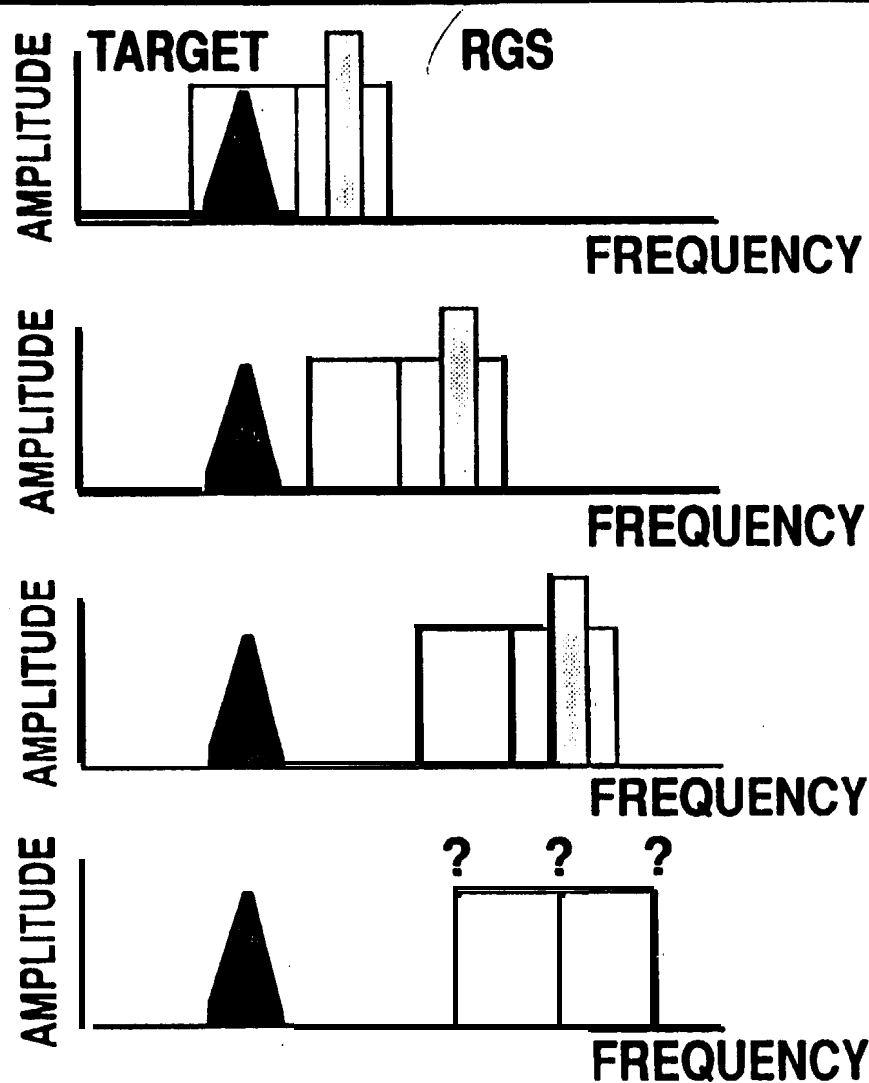
COHERENT AND NON COHERENT CHARACTERISTICS



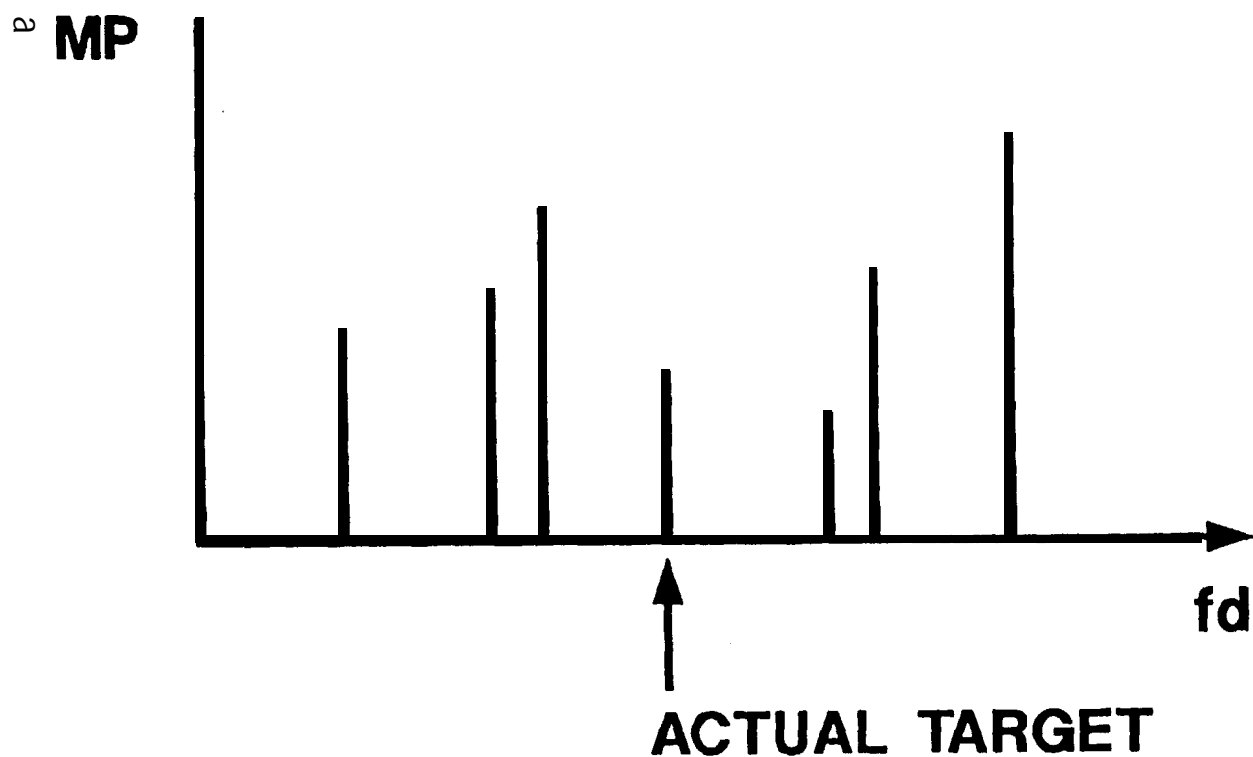
COHERENT RADAR CHARACTERISTICS



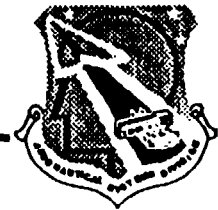
VELOCITY GATE PULL OFF TIME SEQUENCE



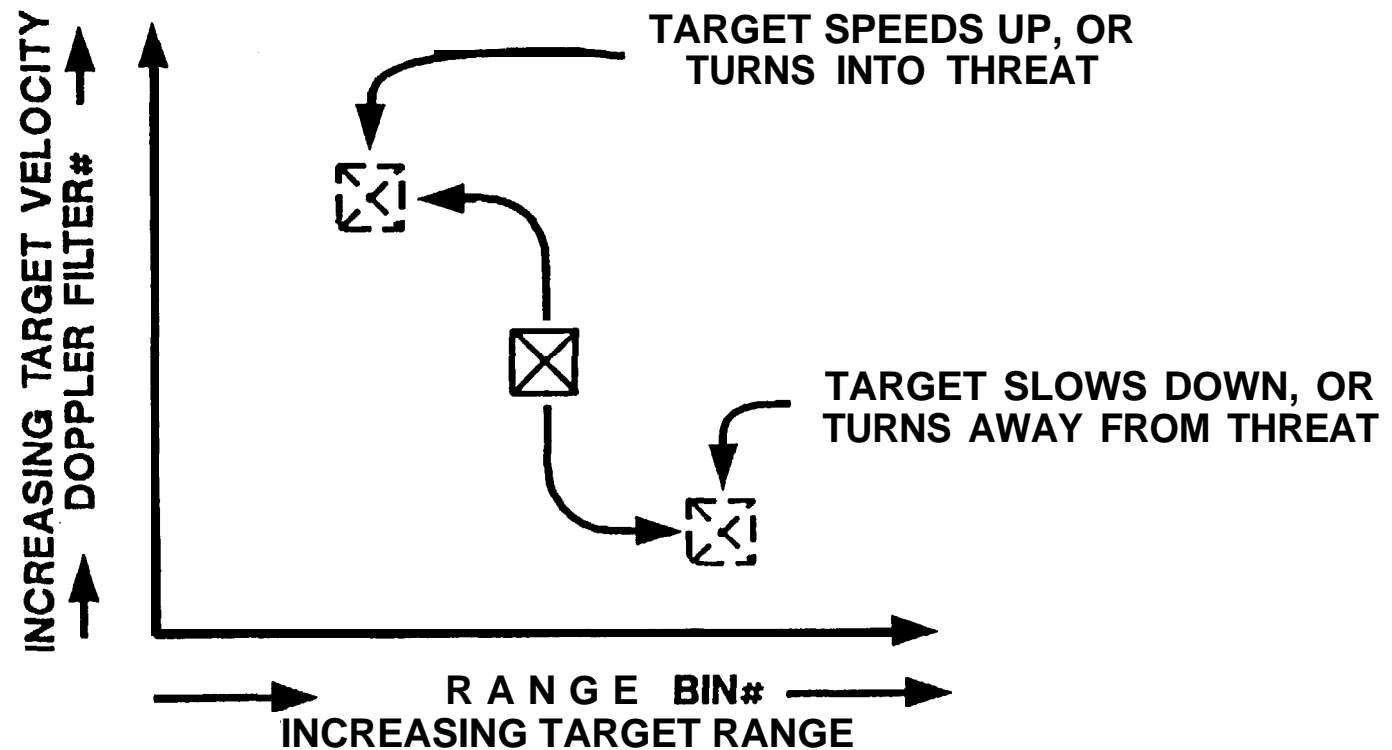
VELOCITY FALSE TARGETS



COMBINED RGPO/VGPO



COMBINED RGPO/VGPO



RW49COM D-173

RADAR COUNTERMEASURES



TRADES & DRIVERS - VELOCITY ECM

- PRESERVATION OF COHERENCY
 - ISOLATION/GAIN/ GAIN MARGIN
 - STABILITY OF UP/DOWN CONVERSION HARDWARE
 - MEMORY UPDATE RATES
- POWER (J/S)
 - BANDWIDTH MATCH
 - MODULATION LOSS
 - MULTIPLEXING LOSS (6dB PER ADDITIONAL THREAT)
- JAM CUES
 - SPECTRAL PURITY
 - QUANTIZATION NOISE/SPURS
 - UP/DOWN CONVERSION SPURS
 - JEM LINES

AGENDA



SURVIVABILITY FACTORS

ECM SYSTEM ARCHITECTURES

RADAR COUNTERMEASURES

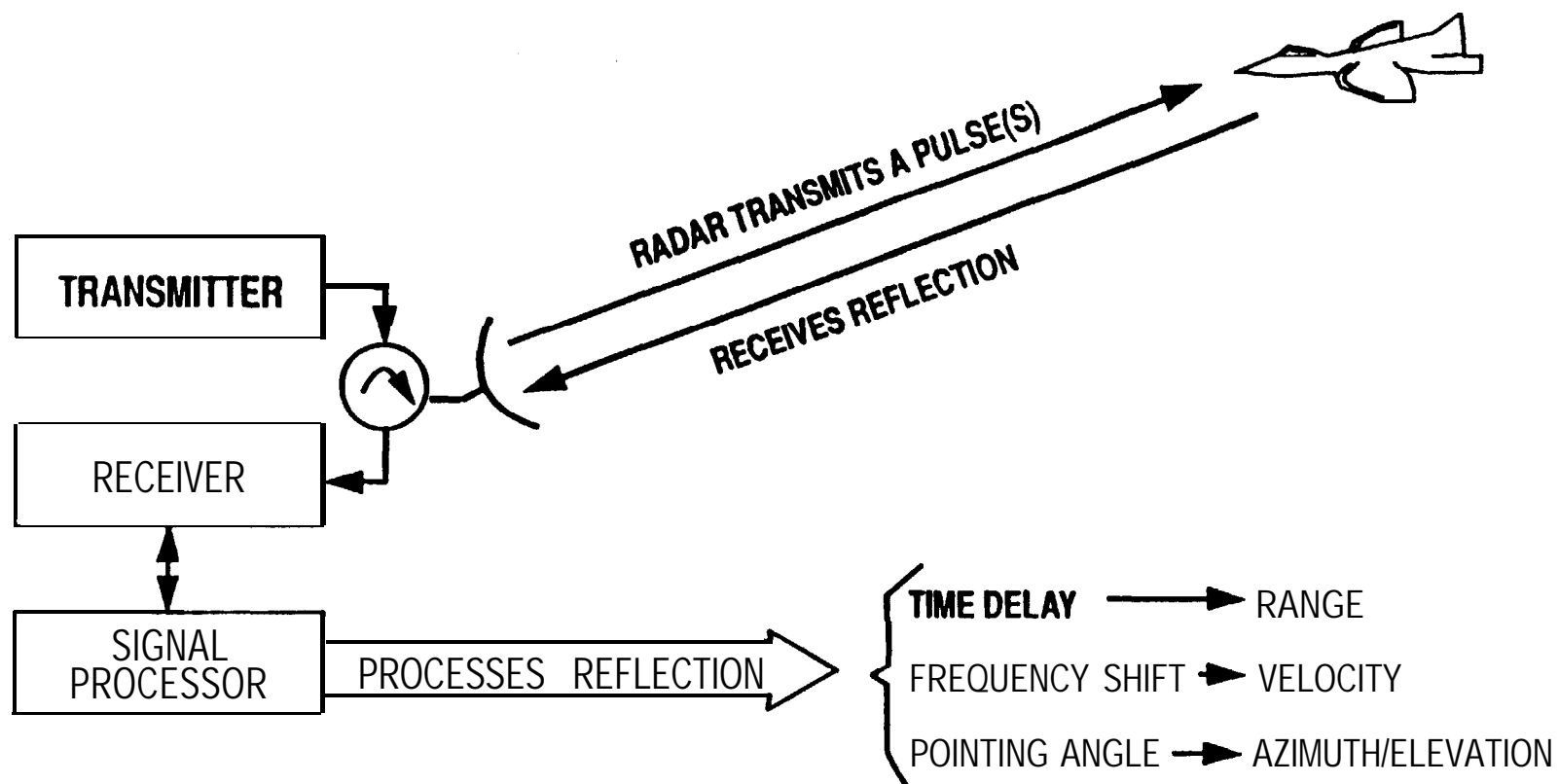
- RANGE
- VELOCITY
- * ANGLE



MISSILE COUNTERMEASURES .

COUNTERMEASURES VV RAPUP

ECM ANALYSIS - TOOLS AND PROCESSES



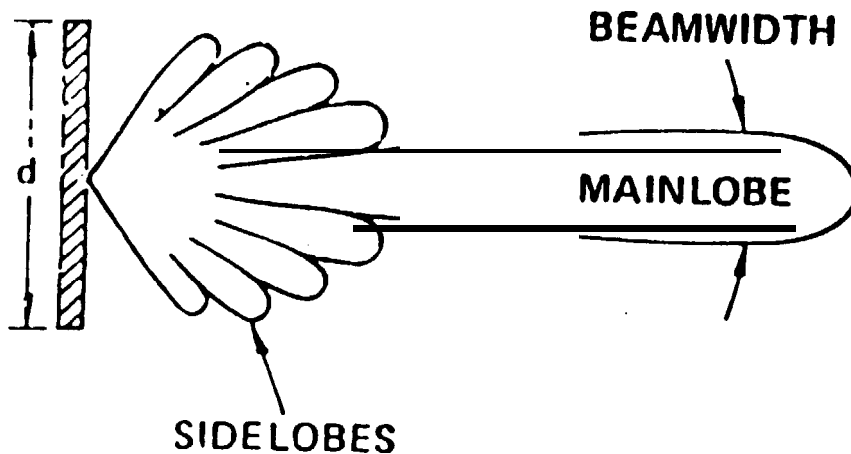
RADAR COUNTERMEASURES



ANGLE TRACKING CHARACTERISTICS

- . AZIMUTH/ELEVATION TRACKING IN ADDITION TO RANGE AND/OR VELOCITY
- . UTILIZES ANTENNA BEAM SHAPE FOR ANTENNA POINTING
- . USE RANGE OR DOPPLER (BINS/GATES/CELLS) TO REDUCE NOISE, CLUTTER, JAMMING, INTERFERENCE TO TRACK ONLY SIGNAL
- . SINGLE ANGLE CHANNEL
 - . USES SINGLE ANTENNA BEAM
 - . TARGET POSITION - RETURN @ MAXIMUM AMPLITUDE
 - . SUSCEPTIBLE TO AMPLITUDE MODULATION ECM
 - . ACTIVE/PASSIVE TRACK WHILE SCAN (**TWS**), CONICAL/SEQUENTIAL SCAN
- . MULTIPLE ANGLE CHANNELS (MONOPULSE)
 - . COMPARES MULTIPLE ANTENNA BEAMS
 - . TARGET POSITION - WHERE ANGLE ERROR IS ZERO
 - . NULLIFIES CONVENTIONAL AM
 - . SUSCEPTIBLE TO MORE SOPHISTICATED TECHNIQUES

THE ANTENNA PROVIDES ANGLE MEASUREMENT



BEAMWIDTH

$$\theta_{3\text{ dB}} \propto \frac{\lambda}{d} = \frac{\text{WAVELENGTH}}{\text{ANT DIAMETER}}$$

AT X-BAND

$$\theta_{3\text{ dB}} \approx \frac{85^\circ}{d}$$

(FOR TAPERED ILLUM)

$$\theta_{3\text{ dB}} \approx \frac{70^\circ}{d}$$

(FOR UN-TAPERED)

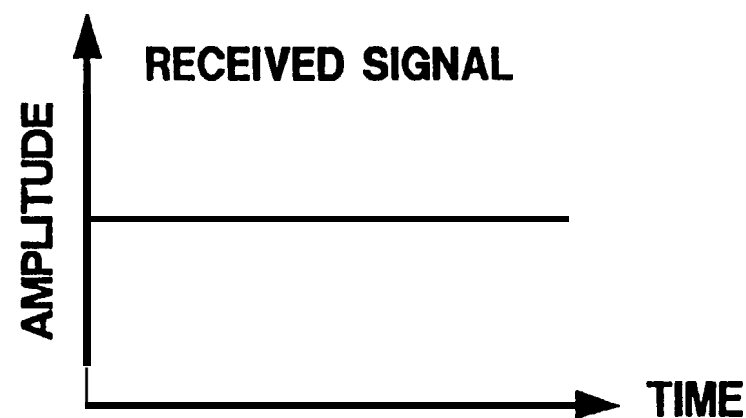
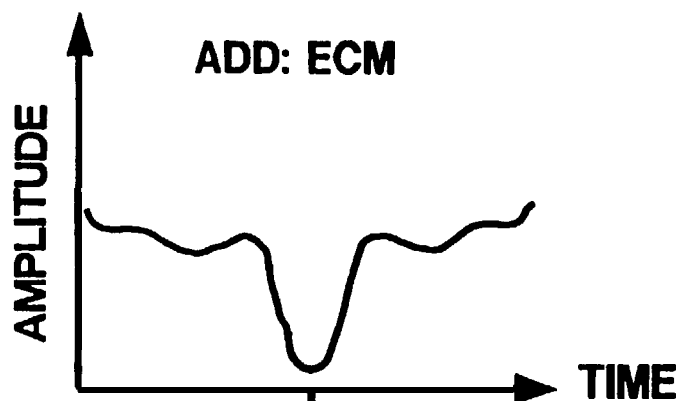
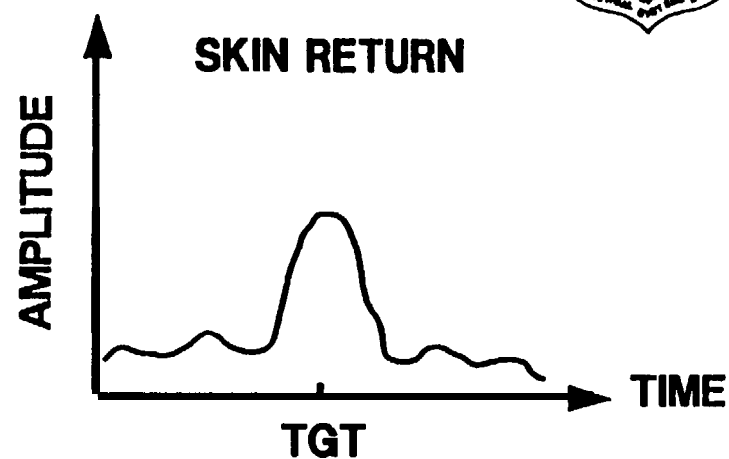
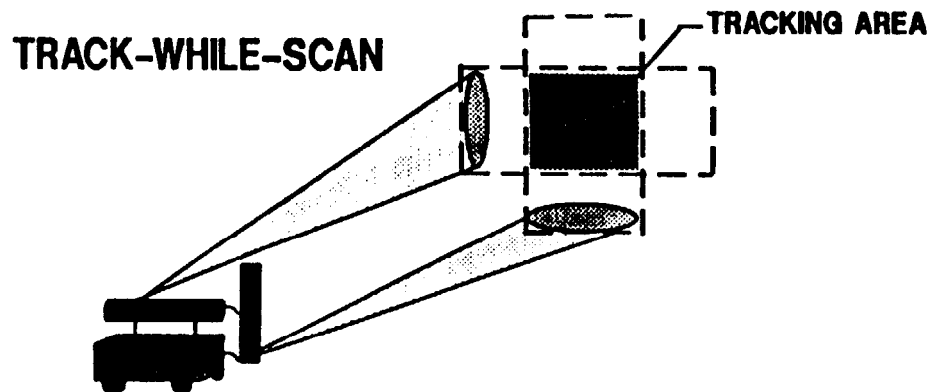
RADAR COUNTERMEASURES



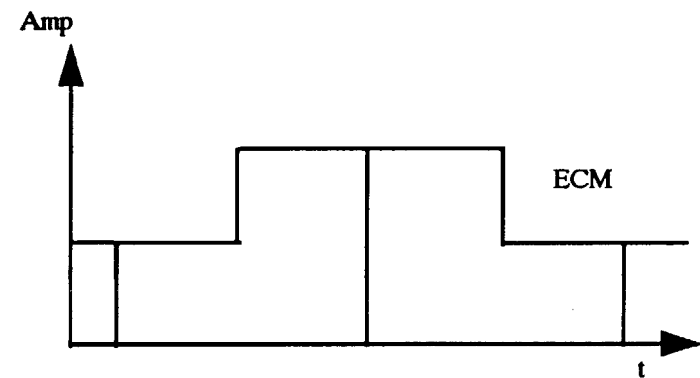
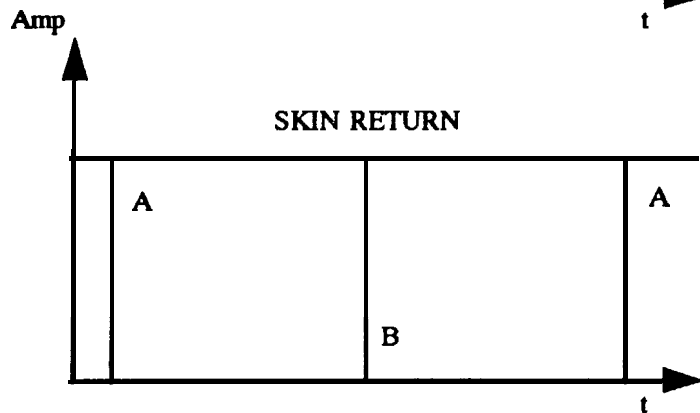
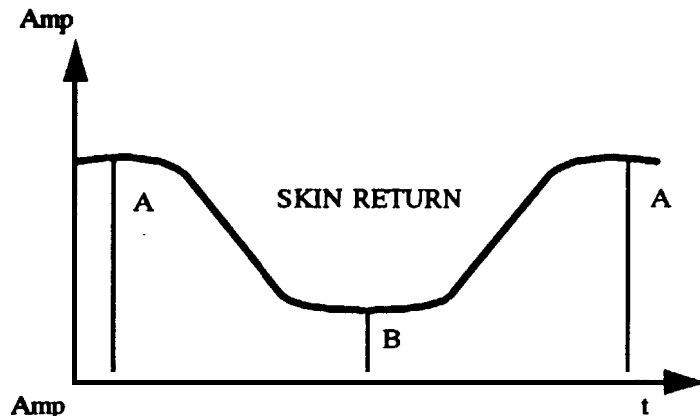
ANGLE ECM TECHNIQUES

- AMPLITUDE MODULATION
 - INVERSE GAIN
 - INVERSE CONICAL SCAN
 - SWEPT SQUARE WAVE
- MONOPULSES
 - POLARIZATION
 - CROSS-EYE
 - CHAFF

INVERSE GAIN VS TRACK-WHILE-SCAN

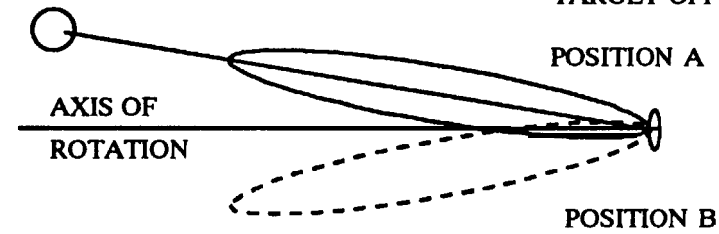


SCAN RELATED AMPLITUDE MODULATION VS CONICAL SCAN



CONICAL SCAN

TARGET



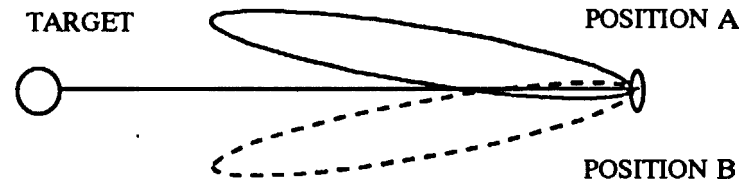
TARGET OFF AXIS

POSITION A

AXIS OF
ROTATION

POSITION B

TARGET

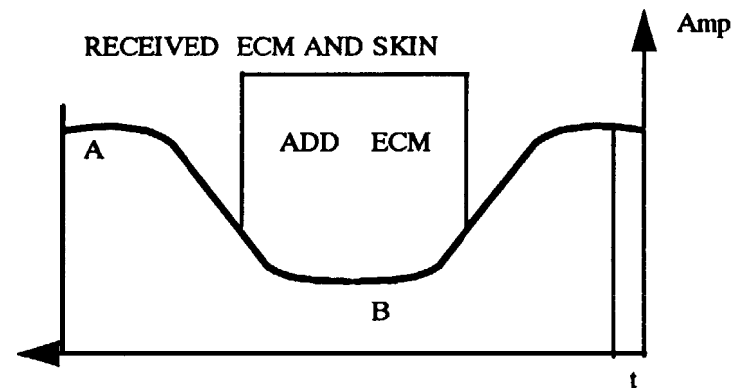


TARGET ON AXIS

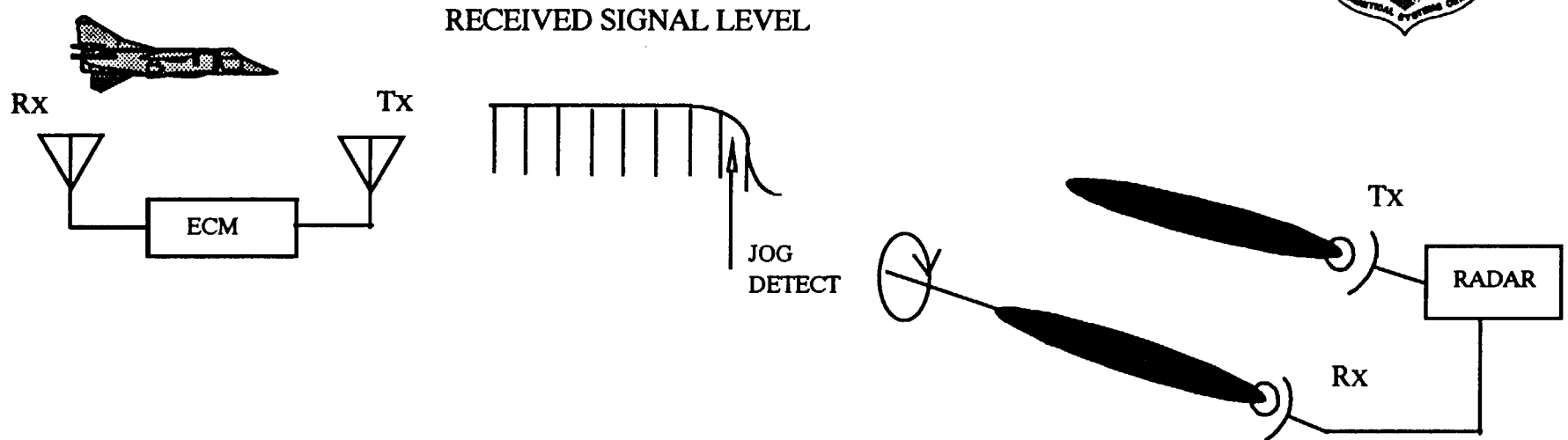
POSITION A

POSITION B

RECEIVED ECM AND SKIN

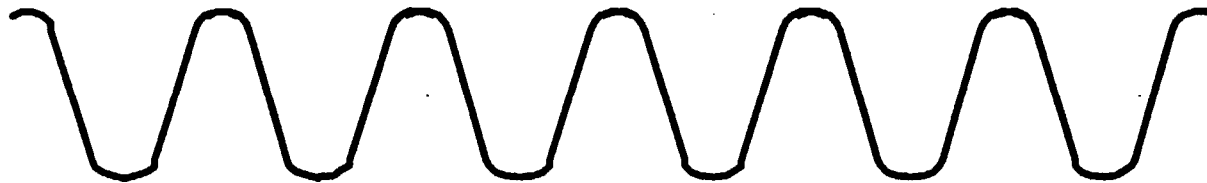


SWEPT AM VS PASSIVE SCAN



Radar Receive Scan

60 Hz



ECM

30 Hz

50 Hz

60 Hz



N

RADAR COUNTERMEASURES



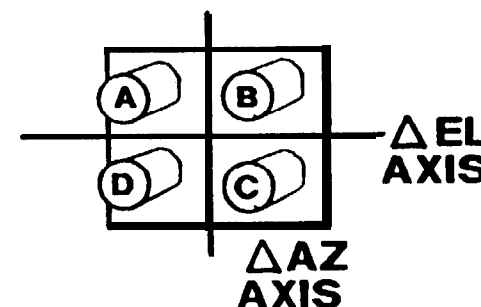
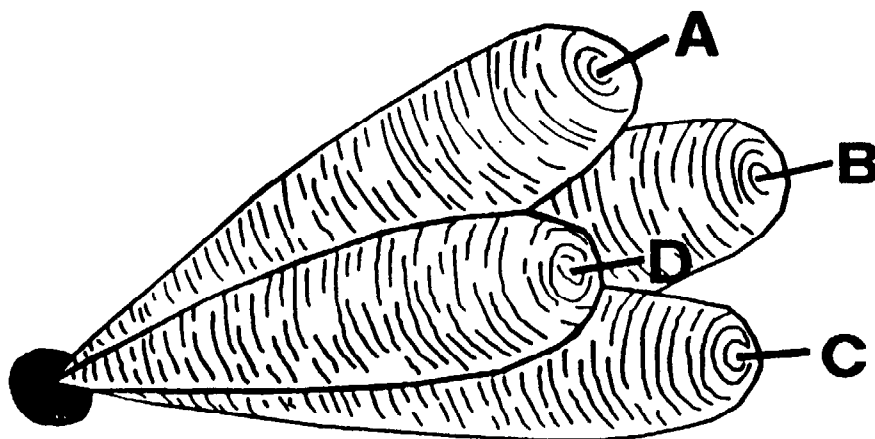
TRADES & DRIVERS - AMPLITUDE MODULATION

- . TECHNIQUE GENERATOR COMPLEXITY
- . DETECTION & TRACKING
 - . SIGNAL AMPLITUDE
 - . SCAN RATE & PHASE
 - . DEPTH OF MODULATION
 - . MONITORING OF SIGNAL AMPLITUDE (FOR JOG DETECT)
- . MODULATION
 - . SCAN FREQUENCY SET-ON ACCURACY
 - . PHASE SET-ON ACCURACY
 - . DUTY CYCLE
 - . DEPTH OF MODULATION

MONOPULSE



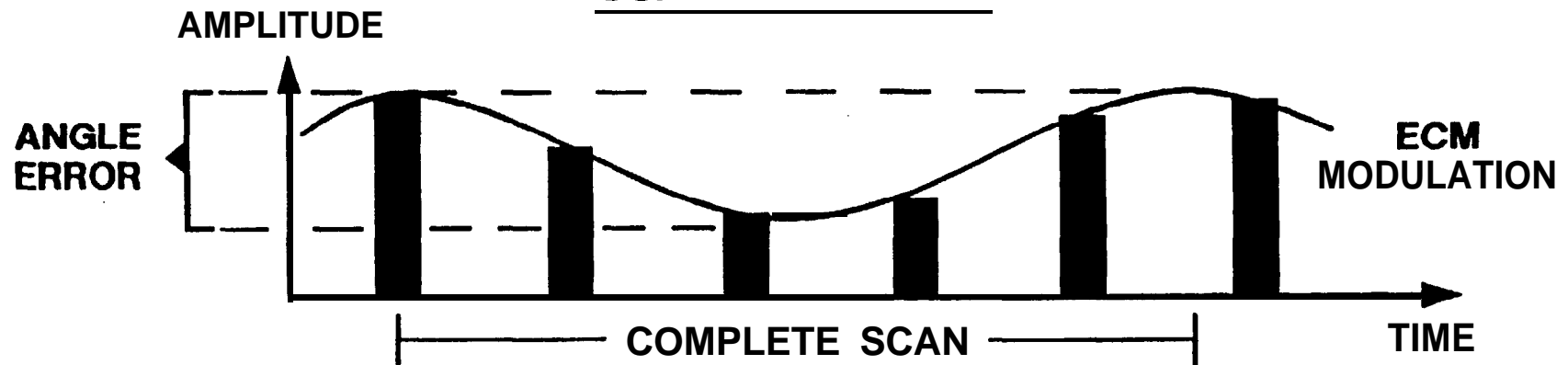
- FOUR SIMULTANEOUSLY RECEIVE BEAMS.
- ANGLE ERRORS DERIVED FROM INSTANTANEOUS BEAM COMPARISON
 - AZIMUTH ERROR = $(A + D) - (B + C)$
 - ELEVATION ERROR = $(A + B) - (C + D)$TIME INDEPENDENT
- TARGET BORESIGHTED WHEN $A=B=C=D$



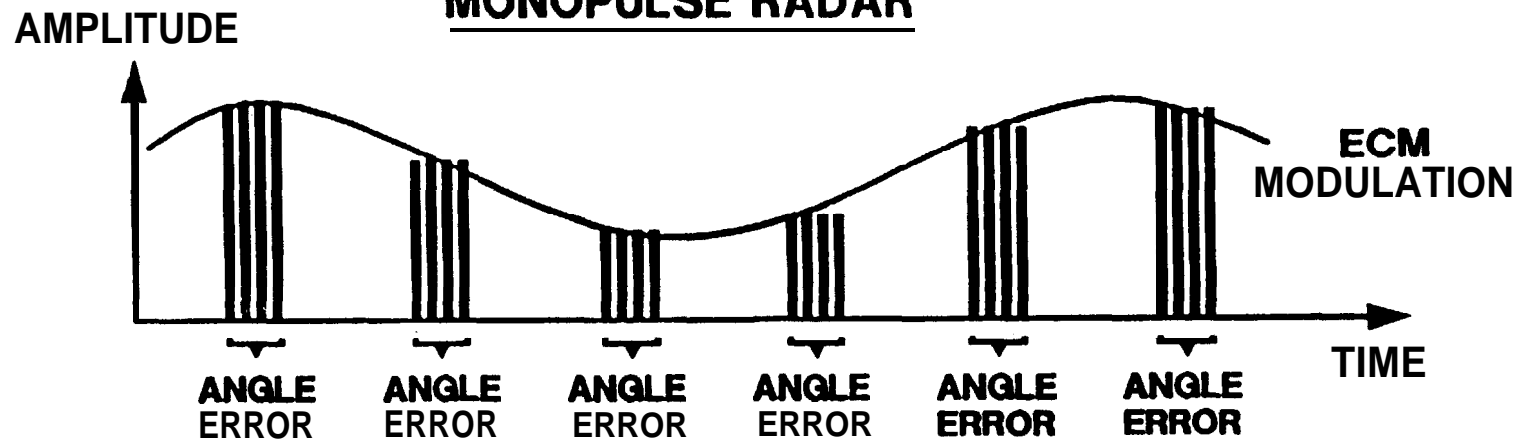
MONOPULSE IMPACTS



SCANNING RADAR



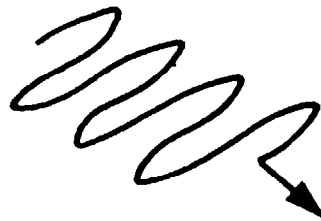
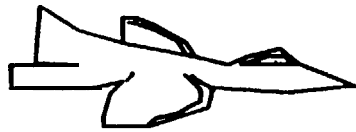
MONOPULSE RADAR



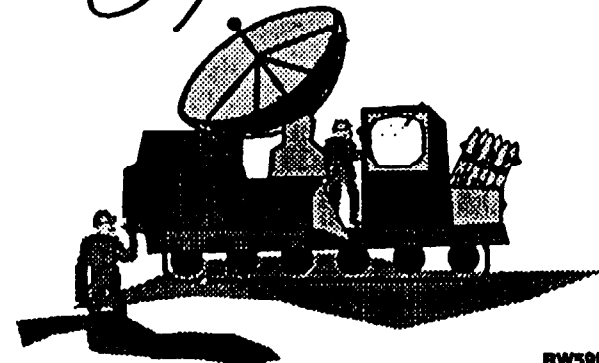
POLARIZATION



**TRANSMITTED
POLARIZATION ECM
(HORIZONTAL)**



**TRANSMITTED
RADAR SIGNAL
(VERTICAL)**

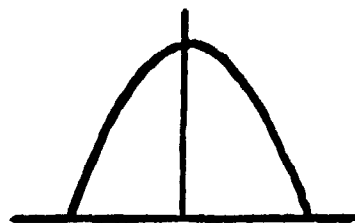




UNCLASSIFIED

POLARIZATION CHARACTERISTICS IN A MONOPULSE ANTENNA

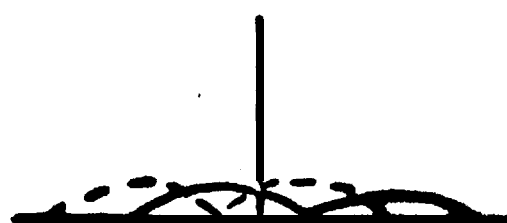
BASIC
ANTENNA
PATTERN



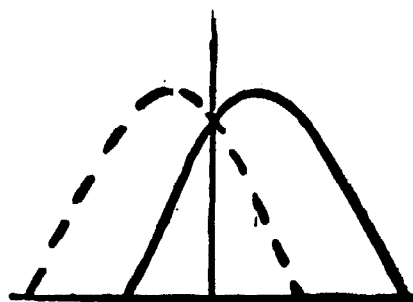
PRINCIPAL POLARIZATION



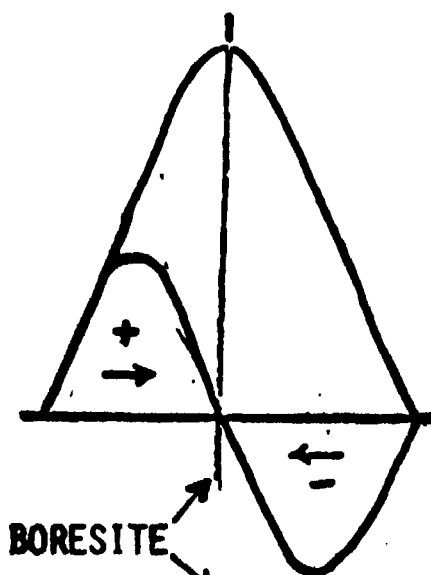
CROSS POLARIZATION



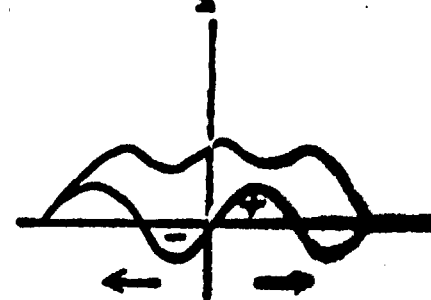
MONOPULSE
ANTENNA
(ONE PLANE)



SUM & DIFFERENCE
PATTERNS



BORESITE



UNCLASSIFIED

RADAR COUNTERMEASURES



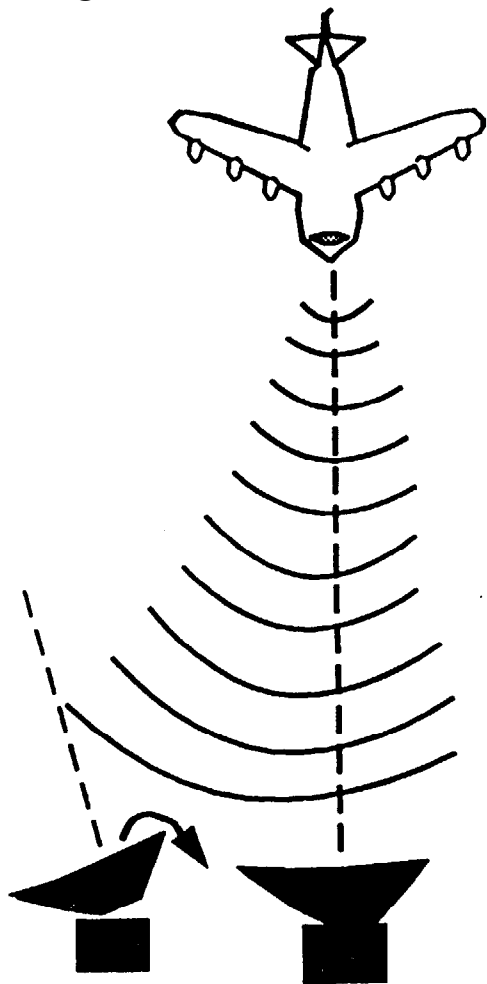
TRADES & DRIVERS - POLARIZATION ANGLE ECM

- THREAT VULNERABILITY
 - MONO-STATIC vs BISTATIC
 - CROSS-POLARIZATION RESISTANCE
- SYSTEM COMPLEXITY - SPECIALIZED Rx/Tx
 - POLARIZATION UPDATE RATE
 - LOOKTHROUGH
 - MULTIPATH
 - POLARIZATION SET ON ACCURACY (PURITY)
- OFTEN DEPENDENT ON RANGE OR VELOCITY PULL TO ACHIEVE INFINITE J/S

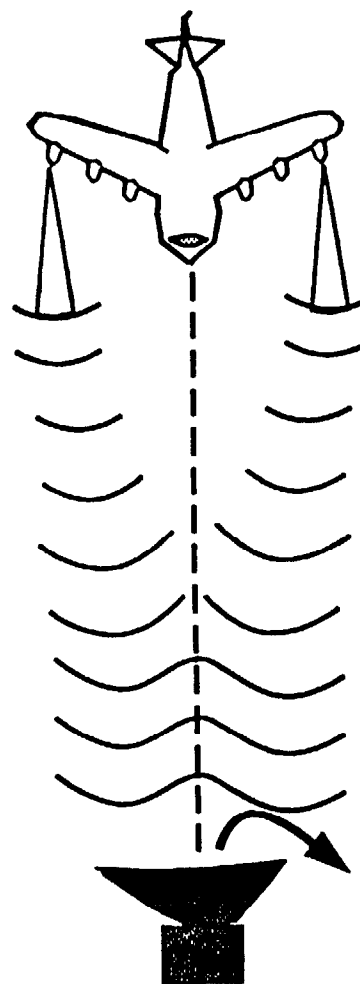
CROSS-EYE



NORMAL RADAR TRACKING



CROSS-EYE



**RADAR TRIES
TO ALIGN
ANTENNA
WITH
TILTED PHASE
FRONT**

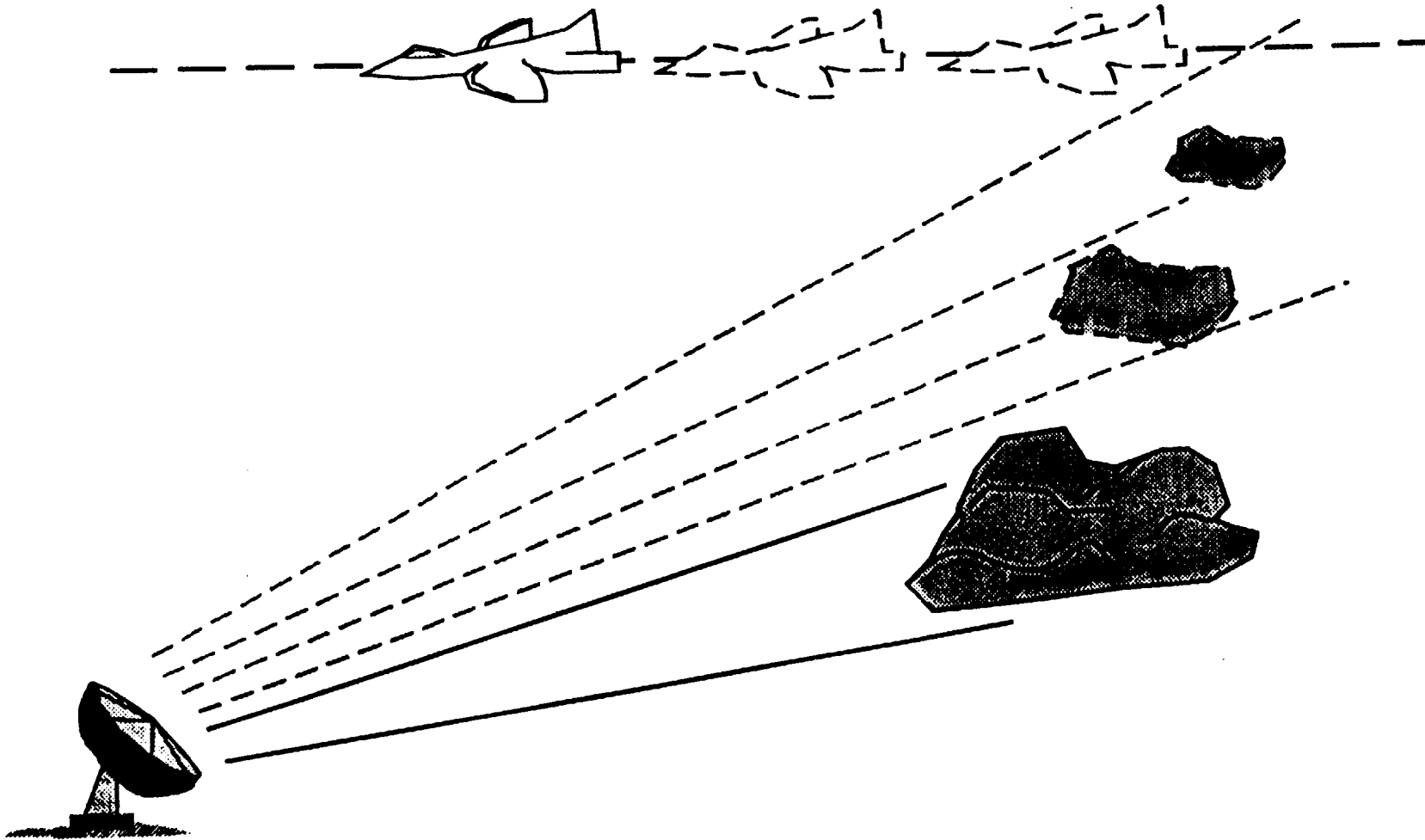
RADAR COUNTERMEASURES



TRADE & DRIVERS - CROSS-EYE ANGLE ECM

- RADAR - MONOSTATIC vs BISTATIC
- SYSTEM COMPLEXITY - SPECIALIZED Rx/Tx
 - PHASE MATCHING
 - SYSTEM DELAYS
- OFTEN DEPENDENT ON RANGE OR VELOCITY PULL TO ACHIEVE INFINITE J/S

SELF PROTECTION CHAFF



RW648E DKJ170

RADAR COUNTERMEASURES



TRADE & DRIVERS - CHAFF ANGLE ECM

- **DISPENSE RATE**
- **BLOOM RATE/SIZE**
- **VELOCITY OF DIPOLES VS DOPPLER TRACKERS**
- **EFFECTIVE CROSS SECTION OF CHAFF CLOUD**
- **WEATHER**
- **AIRCRAFT MANEUVER**

AGENDA



SURVIVABILITYFACTORS

ECMSYSTEMARCHITECTURES

RADARCOUNTERMEASURES

- * RANGE
- VELOCITY
- ANGLE

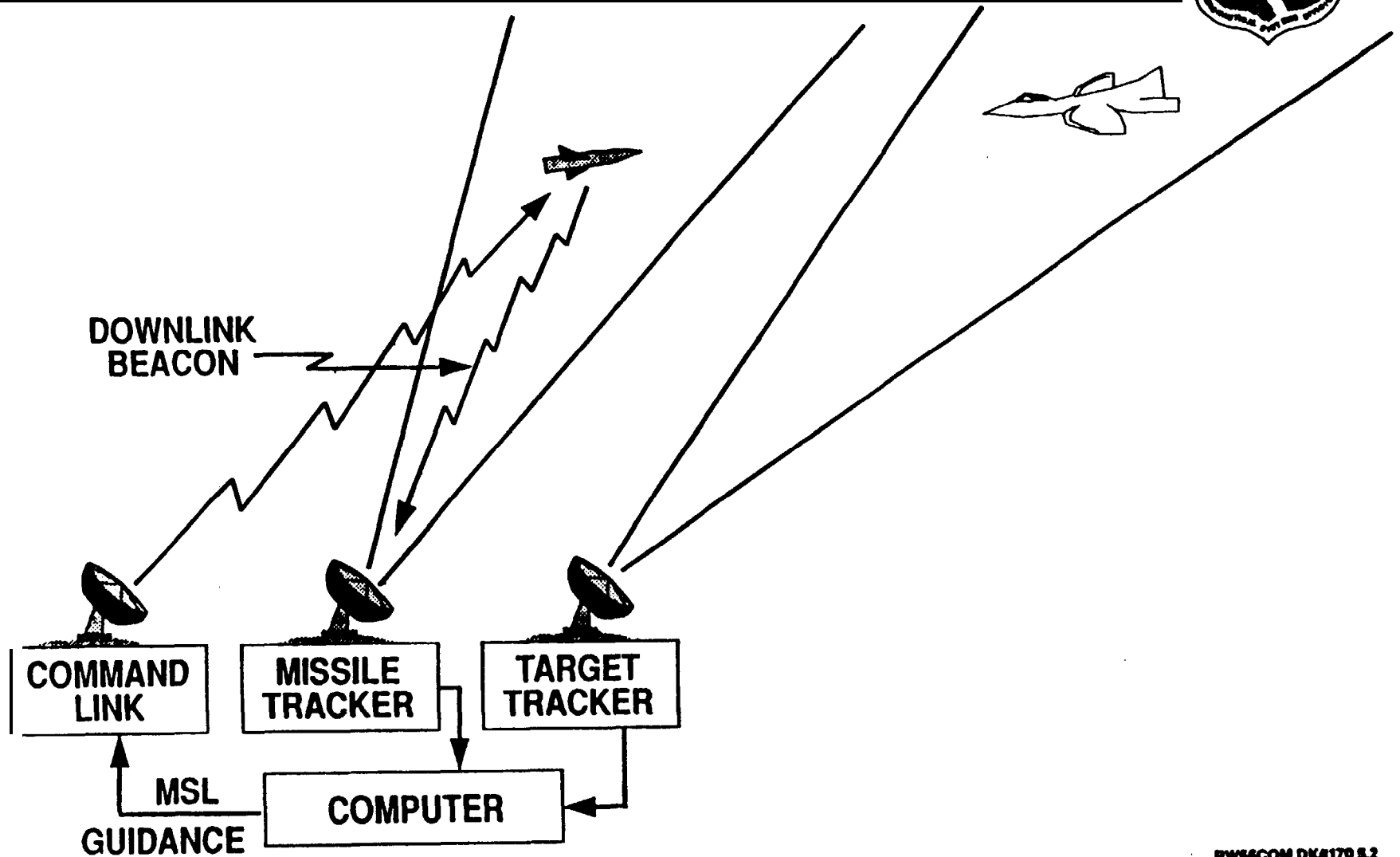


MISSILECOUNTERMEASURES

COUNTERMEASURES WRAPUP

ECMANALYSIS-TOOLSANDPROCESSES

COMMAND MISSILE GUIDANCE



MISSILE COUNTERMEASURES



COMMAND GUIDED WEAPON JAMMING APPROACH:

- ATTACK MULTIPLE ASPECTS OF WEAPON SYSTEM
- FALSE TARGET POSITION VERSUS TARGET TRACK RADAR (TTR)
 - RANGE - FALSE TARGETS (RFT/RANRAP), MASKING - NOISE
 - ANGLE - ANGLE ERROR - AM, XPOL

DOWN LINK JAMMING:

- FALSE MISSILE POSITION VERSUS MISSILE TRACKING RECEIVER
 - RANGE - FALSE RANGE POSITION
 - ANGLE - LINE OF SIGHT WITH TARGET, NOT WITH MISSILE
 - DENY MISSILE TRACK
- COMMAND LINK - (UPLINK)
 - ISSUES INCORRECT FLIGHT COMMANDS TO MISSILE
 - MISSILE FLYS TO WRONG RANGE/ANGLE FOR INTERCEPT

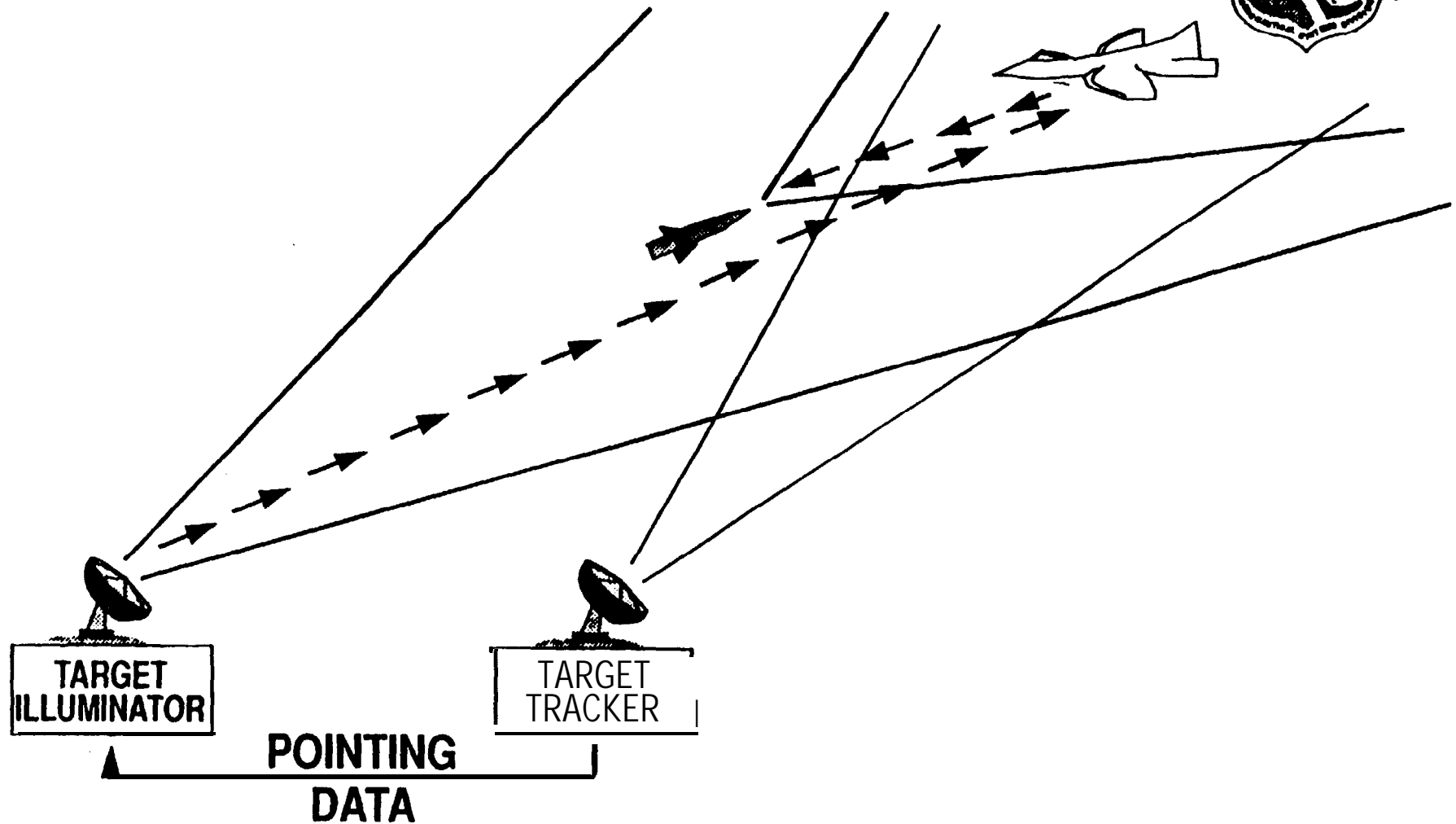
MISSILE COUNTERMEASURES



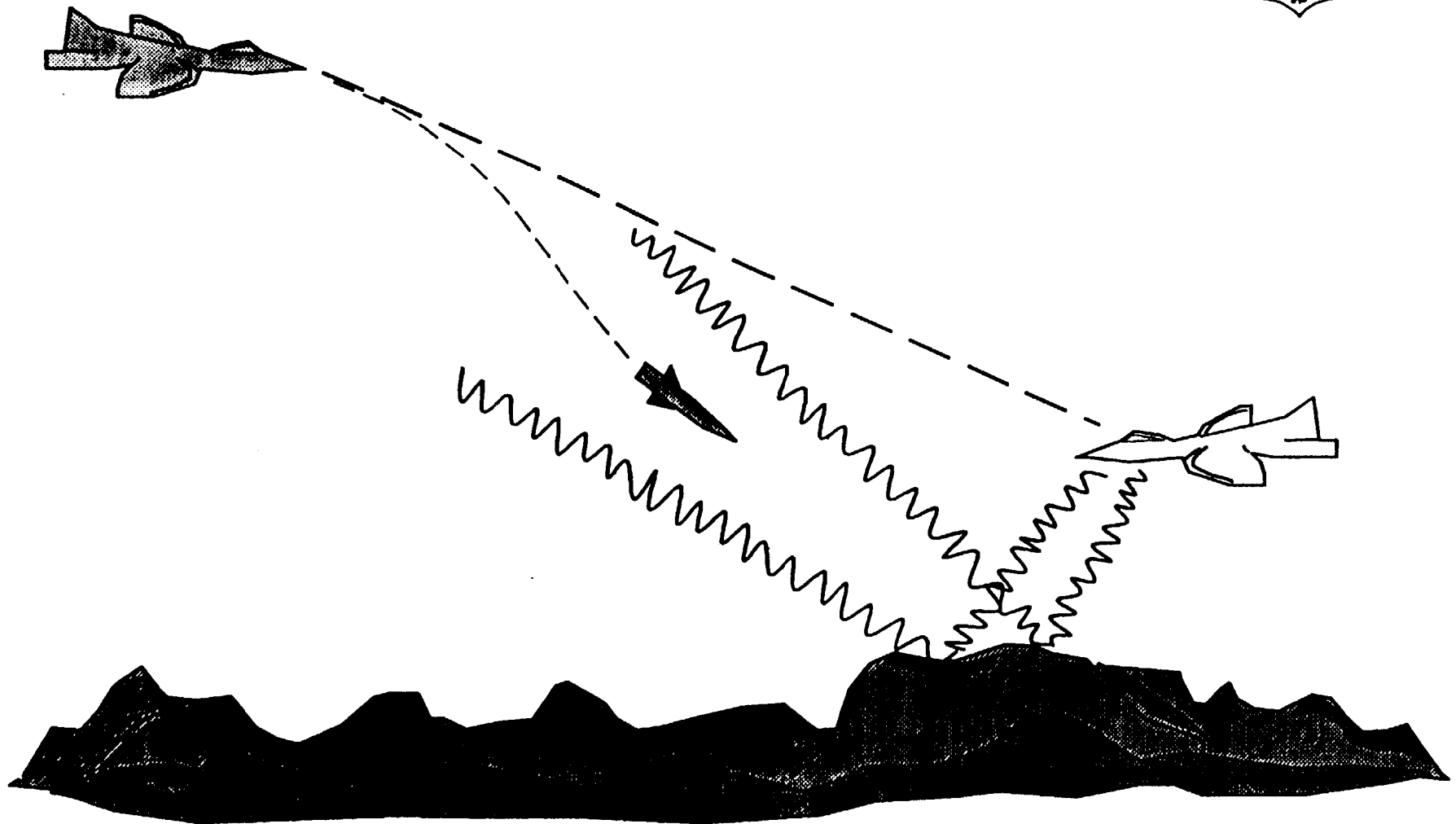
TRADES & DRIVERS - COMMAND GUIDED MISSILE CM (DOWN LINK JAMMING)

- REQUIRES HIGH POWER TO BE EFFECTIVE
 - JAM TO BEACON (J/B) RATIO
 - APRIORI KNOWLEDGE OF BEACON FREQUENCY OR ABILITY TO MEASURE BEACON FREQUENCY
- REQUIRES HIGH DUTY CYCLE FROM JAMMER
 - @ 'MULTIPLE ECM PULSES FOR EACH RADAR PULSE
 - TIME/FREQUENCY MULTIPLEXING TO COVER UNCERTAINTY

SEMI-ACTIVE MISSILE GUIDANCE SYSTEM



TERRAIN B° UNCE



RW60TER DK6170 5.2

MISSILE COUNTERMEASURES

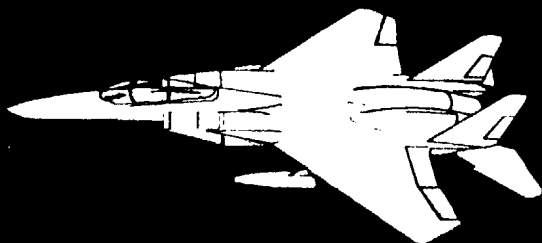


TRADES & DRIVERS - TERRAIN BOUNCE MISSILE CM

- . **ATTACKS SEMI-ACTIVE AND ACTIVE MISSILES**
- . THREAT CAPABILITY - TWO TARGET PROCESSING/CCM
- $(J/S)_{\text{DIRECT}}$ VS $((J)_{\text{INDIRECT}} / (J+S)_{\text{DIRECT}})$
- . POWER DENSITY DIMISHES WITH ALTITUDE
- . ANTENNA TRADES
 - . MAINLOBE GAIN/BEAMWIDTH
 - . DEPRESSION ANGLE
 - . SIDELobe SUPPRESSION
- . TERRAIN REFLECTIVITY
 - . VARIES WITH TERRAIN TYPE
 - . DOPPLER SPREAD
 - . TIME DELAY



Affordable, Effective Countermeasures Against Critical RF Threats



ON-BOARD SYSTEMS

- DECOY SYSTEM
 - CONTROLLER
 - POWER SUPPLY
 - LAUNCHER

THREAT WARNING SYSTEM
DIRECTION OF ARRIVAL

- TECHNIQUES GENERATOR
 - RECEIVE
 - MODULATE
 - RF - OPTIC CONVERSION

DECOY TOW LINE

- POWER TRANSMISSION
- CONTROLLER - DECOY COMMUNICATIONS

- OPTICAL SIGNAL TRANSMISSION

OFF-BOARD DECOY

- SELF-CONTAINED REPEATER
 - RECEIVE
 - MODULATE
 - AMPLIFY
 - TRANSMIT

- DECOY TRANSPONDER
 - OPTIC - RF CONVERSION
 - AMPLIFY
 - TRANSMIT

MISSILE COUNTERMEASURES



TRADES & DRIVERS - TOWED DECOY MISSILE CM

- THREAT CAPABILITY
 - TWO TARGET PROCESSING CCM'S
 - LETHAL RADIUS
 - FUSING
 - SALVO SHOT
- AIRCRAFT SIGNATURE TO BE PROTECTED
- * GEOMETRY - ZONES OF NO PROTECTION
- TOWED DECOY AERODYNAMIC CHARACTERISTICS
 - LAUNCH CLEARANCE
 - DEPLOYMENT / REDEPLOYMENT SPEED / BRAKING
 - REEL OUT / INCAPABILITY
 - FLIGHT STABILITY
 - LINE LENGTH / DROOP
- QUANTITY TO BE CARRIED

MISSILE COUNTERMEASURES



TRADES & DRIVERS - REPEATER TOWED DECOY

- SIMPLE ARCHITECTURE
- LIMITED ELECTRONIC GAIN - DUE TO ISOLATION OF CLOSELY SPACED TRANSMIT AND RECEIVE ANTENNAS
- DOPPLER MODULATION RESULTS IN SPECTRAL SPREADING & LOSS OF J/S
- THREAT RANGE RESOLUTION LIMITS TOW LINE LENGTH
 - GEOMETRY
 - DELAY
- POTENTIAL BEACONING TO UNWANTED THREATS FOR BROADBAND OPERATION

MISSILE COUNTERMEASURES



TRADES & DRIVERS - TRANSPONDER TOWED DECOY

- COMPLEX ARCHITECTURE
 - RECEIVE/TECHNIQUE GENERATION ON BOARD
 - REMOTE TRANSMITTER
- ELECTRONIC GAIN- HIGHER DUE TO WIDE ANTENNA SEPARATION
- LONGER TOW LENGTH POSSIBLE
- GEOMETRY ISSUES REMAIN
- COMPLEX MODULATIONS POSSIBLE
 - DOPPLER
 - RANGE TECHNIQUES - OVERCOME DELAYS
- MINIMIZES BEACONING - USE OF THREAT SPECIFIC TECHNIQUES

AGENDA



SURVIVABILITYFACTORS

ECMSYSTEMARCHITECKJRES

RADARCOUNTERMEASURESTECHNIQUES

- *RANGE
- VELOCITY
- *ANGLE

MISSILECOUNTERMEASURES

WCOUNTERMEASURESWRAPUP

ECMANALYSIS-TOOLSANDPROCESSES

COUNTERMEASURES - WRAP UP



REQUIREMENTS AND STRATEGY DERIVED FROM:

- THREAT ENVIRONMENT
 - IADS - C3 VULNERABILITY
 - SIGNAL DENSITY
 - RADAR CAPABILITIES (RANGE, DOPPLER, ANGLE)
 - MISSILE CAPABILITY (CG, SA, A)
- AIRCRAFT
 - SIGNATURE
 - FLIGHT ENVELOPE

COUNTERMEASURES GOALS

- DELAY/NEGATE ALL STEPS OF RADAR/MISSILE ENGAGEMENT

COUNTERMEASURES-WRAP UP



SYSTEM ARCHITECTURE

- . **ISOLATION/SYSTEM** GAIN VS TARGET RETURN
- . CONSTANT GAIN VS CONSTANT POWER
- **LOOKTHROUGH,LOOKOVER,CHOP**
- . COHERENCY

COUNTERMEASURES TECHNIQUES

- . COUNTER RANGE, VELOCITY, AND ANGLE
- RADAR OPERATION & ECCM'S
- @**OPERATOR**

. *MISSILE VULNERABILITIES AND TECHNIQUES*

- . COMMAND GUIDED
- . ACTIVE / SEMI-ACTIVE

AGENDA



SURVIVABILITY FACTORS

ECMSYSTEMARCHITECTURES

RADARCOUNTERMEASURES

- RANGE
- VELOCITY
- ANGLE

MISSILECOUNTERMEASURES

COUNTERMEASURESWRAPUP



ECMANALYSIS-TOOLSANDPROCESSES

EC ANALYSIS - TOOLS AND PROCESSES



EC ANALYSIS TASK

- **EW ENVIRONMENT - COMPLEX**
- **COUNTLESS FACTORS AFFECT EC OUTCOME**
- **MULTIPLE TOOLS AVAILABLE FOR EC TECHNIQUE ANALYSIS**

**WHICH TOOL DO I CHOOSE TO HELP ANALYZE
ECM TECHNIQUES PERFORMANCE?**

DON'T DEFINE THE PROBLEM TO FIT THE TOOL

THE TOOL MUST FIT THE PROBLEM

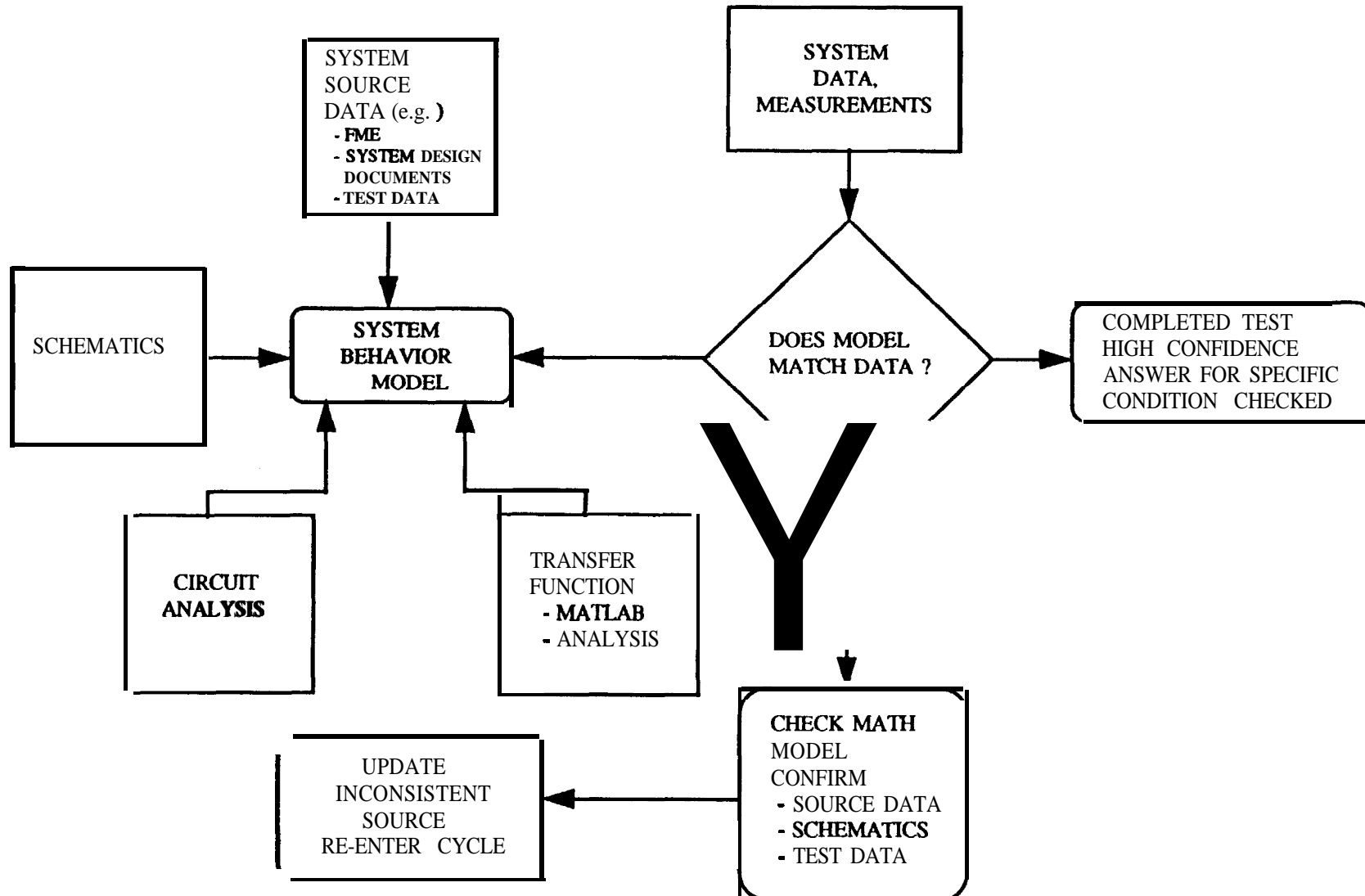
EC ANALYSIS - TOOLS AND PROCESSES



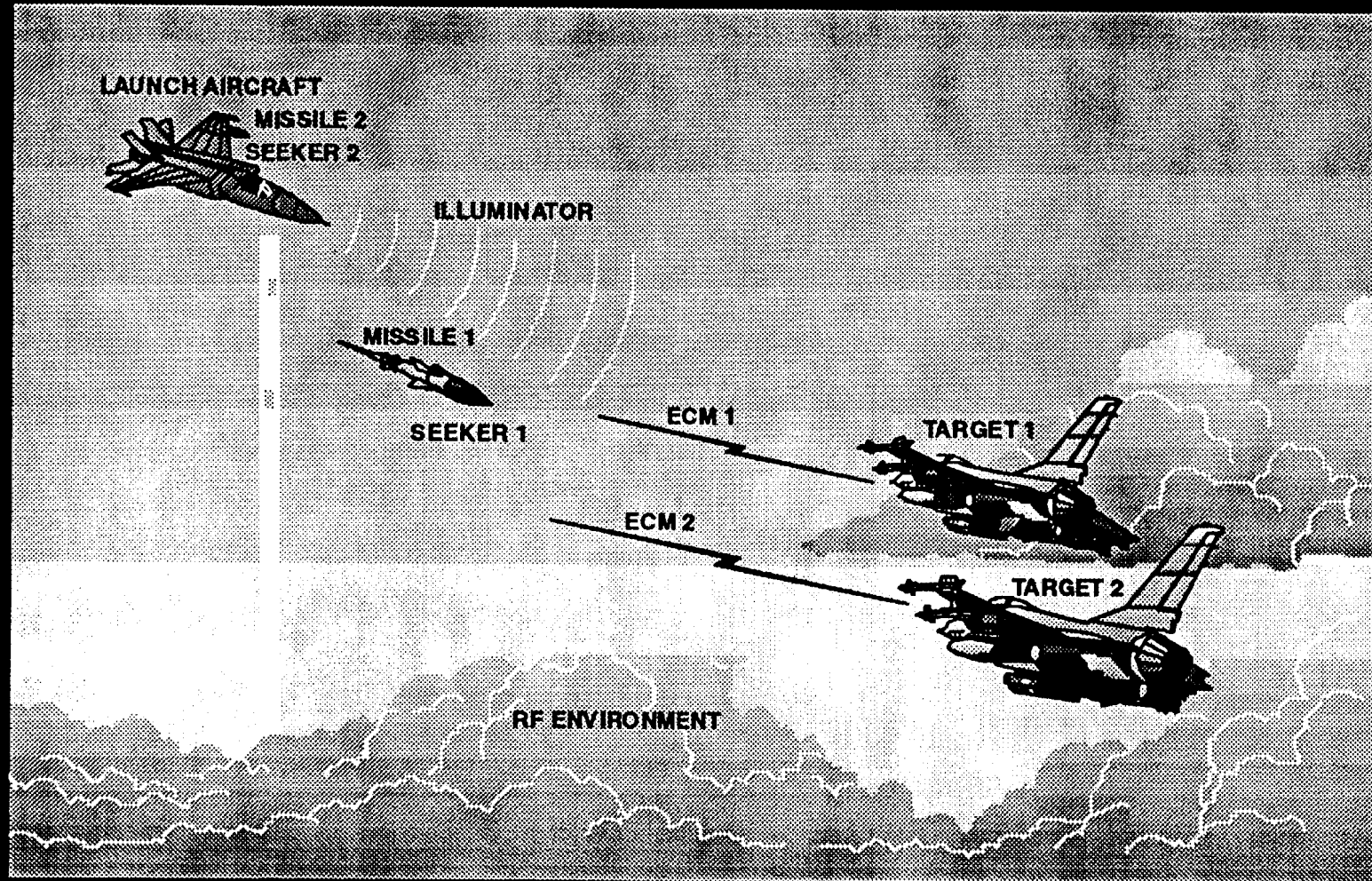
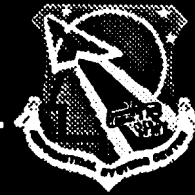
FACTORS TO CONSIDER IN TOOL CHOICE

- . **UNDERSTAND WHAT IS IMPORTANT TO QUESTION BEING ASKED**
 - **NOT FEASIBLE TO CAPTURE ALL REAL WORLD VARIABLES IN A MODEL - ASSUMPTIONS ARE INHERENT - WHAT ARE THEY?**
 - . **CHALLENGE - SELECT & ADEQUATELY TREAT PERTINENT VARIABLES IN THE QUESTION TO BE ANSWERED**
- . **CHECK TO SEE IF IT IS THE RIGHT TOOL**
 - . **MODEL MUST MATCH THE PHYSICS OF THE ISSUE**
 - . **USE HARD THREAT DATA FOR VARIABLES THAT ARE THREAT SENSITIVE**
 - . **REPRESENTATION OF INTELLIGENCE DATA IN THE TOOL MUST ADEQUATELY SUPPORT ADDRESSING THE CRITICAL ISSUE**
- . **UNDERSTAND THE PEDIGREE OF THE TOOL**
 - . **SA-xx or MiG - zz NAMEPLATE - DOES NOT ENSURE FIDELITY**
 - . **WHAT ASPECTS OF TOOL HAVE HIGH FIDELITY?**

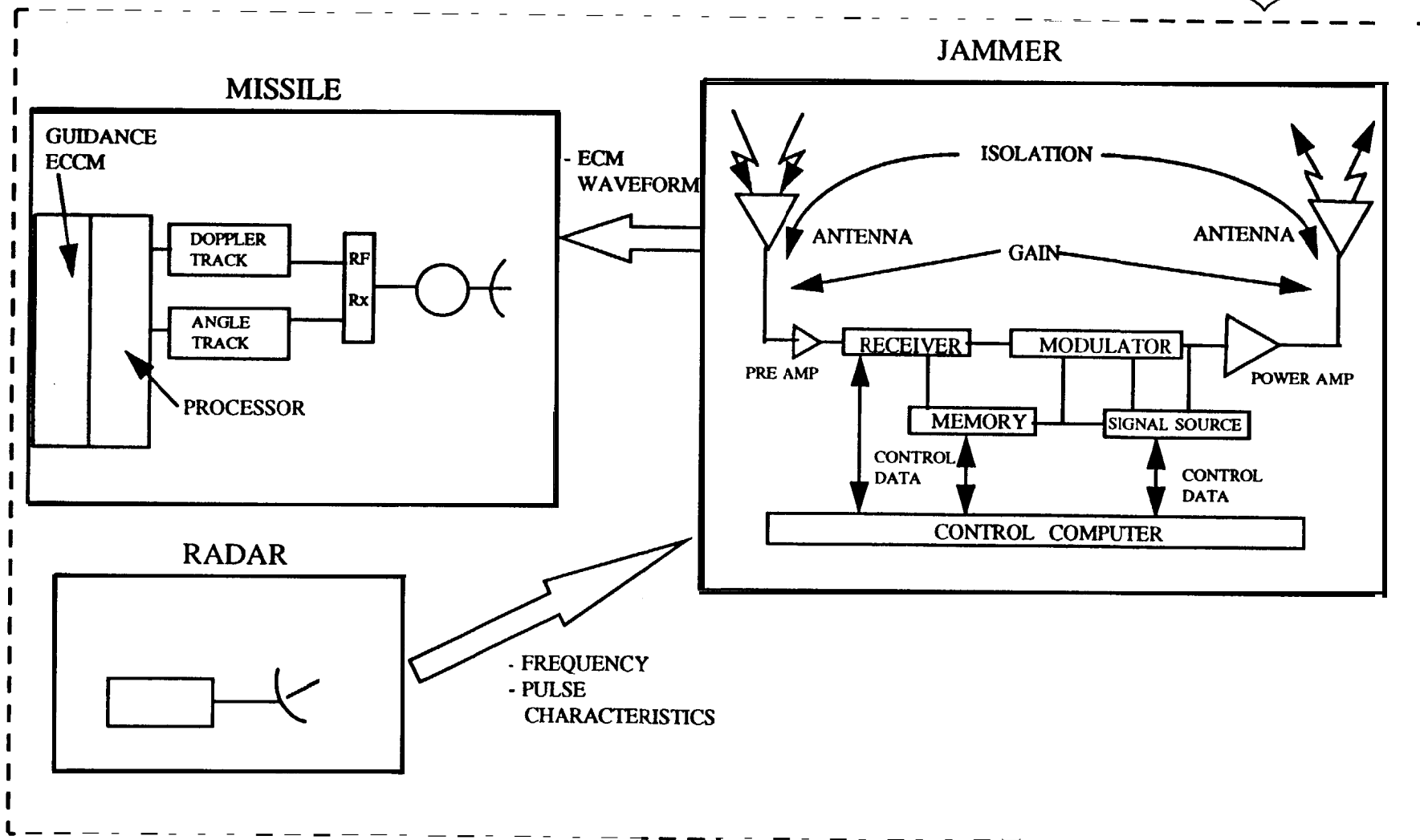
CONFIDENCE PROCESS/OUTPUTS



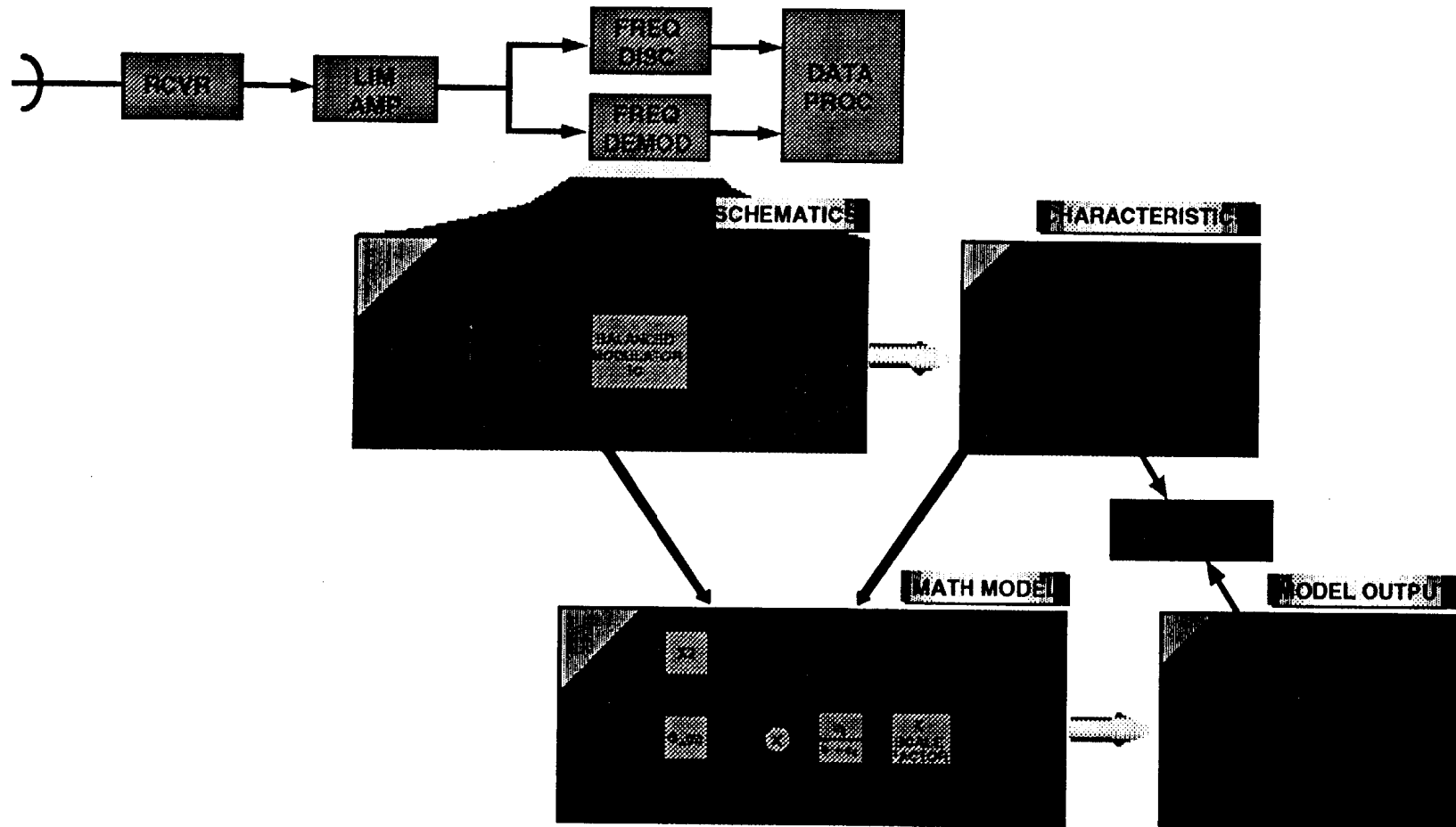
TARGET ENGAGEMENT



TARGET ENGAGEMENT MODEL



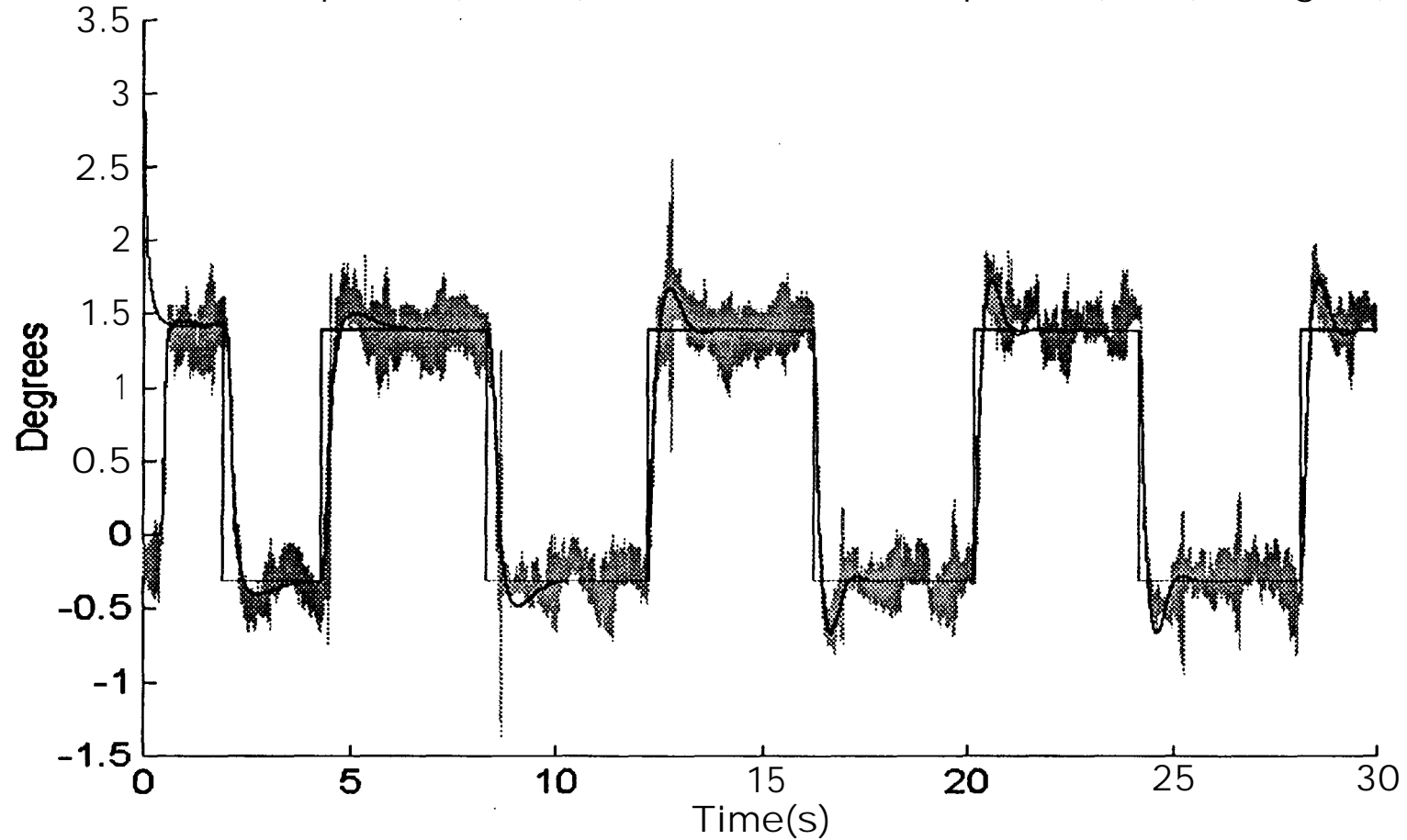
SUBSYSTEM RESPONSE DATA



SYSTEMRESPONSEDATA



Hardware Response (Green) vs. Simulation Response (Blue), Target (Red)



ECMANALYSIS-TOOLSANDPROCESSES



EC EFFECTIVENESS ASSESSMENTS

- HIGH DEGREE OF COMPLEXITY - NUMEROUS VARIABLES
- UNCERTAINTY IN INPUT DATA
- **LIMITATIONS & ASSUMPTIONS IN MODELS/TOOLS**

EC TOOLS DO NOT PROVIDE ANSWERS

EC TOOLS PROVIDE INSIGHT TO INFORMED ANALYSTS IF THE TOOL,
THE INPUT DATA, AND CONSTRAINTS ARE UNDERSTOOD